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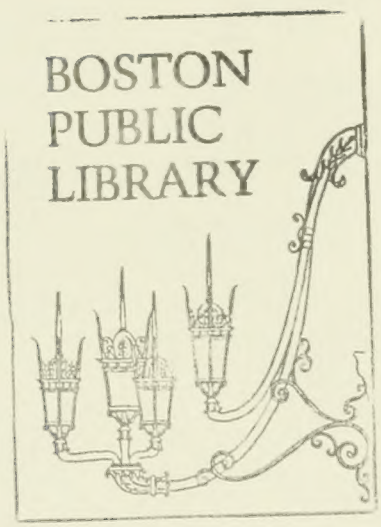
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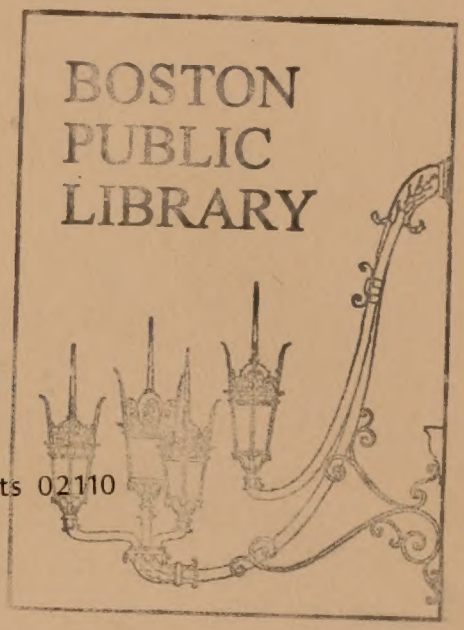
125 SUMMER STREET OFFICE BUILDING

BOSTON, MASSACHUSETTS

FINAL ENVIRONMENTAL IMPACT ASSESSMENT

BOSTON REDEVELOPMENT AUTHORITY



Prepared for:

A.W. Perry, Inc./ Jaymont (USA) Inc.
260 Franklin Street Boston, Massachusetts 02110

Prepared by:

HMM Associates, Inc.
336 Baker Avenue Concord, Massachusetts 01742

April, 1987

125 SUMMER STREET
OFFICE BUILDING
FINAL ENVIRONMENTAL IMPACT ASSESSMENT

March, 1987

Prepared for:

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260 Franklin Street
Boston, Massachusetts 02110

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TABLE OF CONTENTS

		Page
	PREFACE	
1.	EXECUTIVE SUMMARY	1-1
2.	BRA REQUIRED SCOPE OF STUDIES	2-1
	2.1 Comments on DEIA	
	2.2 Response to Comments	
3.	PROJECT DESCRIPTION	3-1
4.	ENVIRONMENTAL IMPACT STUDIES	4-1
	4.1 Pedestrian-level Wind Impact	4.1-1
	4.2 Shadow Impact	4.2-1
	4.3 Daylight Impact	4.3-1
	4.4 Transportation Impacts	4.4-1
	4.5 Air Quality Impacts	4.5-1
	4.6 Noise Impacts	4.6-1
	4.7 Historic Quality Impacts	4.7-1
	4.8 Utility Systems Impacts	4.8-1
	4.9 Energy Impacts	4.9-1
	4.10 Natural Resources Impact	4.10-1
APPENDIX A	WIND	A-1
APPENDIX B	TRANSPORTATION	B-1
APPENDIX C	AIR QUALITY	C-1

LIST OF FIGURES

		Page
3-1	Project Location - 125 Summer Street, Boston	3-2
3-2	125 Summer Street - Existing Conditions	3-3
3-3	Key for Existing Site Views	3-4
3-4	Existing Conditions - View A	3-5
3-5	Existing Conditions - View B	3-6
3-6	Existing Conditions - View C	3-7
3-7	Existing Conditions - View D	3-8
3-8	Existing Conditions - View E	3-9
3-9	Existing Conditions - View F	3-10
3-10	Existing Conditions - View G	3-11
3-11	Existing Conditions - View H	3-12
3-12	Existing Conditions - View J	3-13
3-13	Proposed New Construction - Ground Floor Plan	3-16
3-14	Proposed New Construction - Parking Level One	3-17
3-15	Proposed New Construction - Summer Street Elevation	3-19
3-16	Proposed New Construction - Lincoln Street Elevation	3-20
3-17	Proposed New Construction - Surface Artery Elevation	3-21
3-18	Proposed New Construction - South Street Elevation	3-22
3-19	Site Section Looking Southwest	3-24
3-20	Site Section Looking West	3-25
3-21	Model Photograph Looking Southeast	3-26
3-22	Model Photograph Looking Northeast	3-27
3-23	Summer Street Perspective	3-28
3-24	Proposed New Construction - Dewey Square Perspective	3-29

LIST OF FIGURES (Continued)

		Page
4.1-1	Typical Flow Patterns between High and Low Rise Buildings	4.1-3
4.1-2	Annual Wind Rose	4.1-5
4.1-3	Spring Wind Rose	4.1-6
4.1-4	Summer Wind Rose	4.1-7
4.1-5	Autumn Wind Rose	4.1-8
4.1-6	Winter Wind Rose	4.1-9
4.1.7	Melbourne's Criteria for Average Hourly Pedestrian Winds Compared With Other References	4.1-13
4.1-8	Photograph of Wind Tunnel Model for 125 Summer Street Tests	4.1-15
4.1-9	Boston University Boundary Layer Wind Tunnel	4.1-17
4.1-10	Smoke Test Study Scheme	4.1-19
4.1-11	Local Wind Flow Patterns for North Winds	4.1-22
4.1-12	Local Wind Flow Patterns for Northeast Winds	4.1-23
4.1-13	Local Wind Flow Patterns for East Winds	4.1-25
4.1-14	Local Wind Flow Patterns for Southeast Winds	4.1-27
4.1-15	Local Wind Flow Patterns for South Winds	4.1-28
4.1-16	Local Wind Flow Patterns for Southwest Winds	4.1-30
4.1-17	Local Wind Flow Patterns for West Winds	4.1-31
4.1-18	Local Wind Flow Patterns for Northwest Winds	4.1-32
4.1-19	Study Locations for Quantitative Analysis	4.1-35
4.1-20	Locations 7 and 28 Compared to Melbourne's Criteria for Average Hourly Pedestrian Winds Compared With Other References	4.1-49
4.1-21	Mean Wind Speeds Exceeding 1% of the Time	4.1-56
4.1-22	Gust Wind Speeds Exceeding 1% of the Time	4.1-57
4.2-1	Noontime Solar Altitude Angles	4.2-2
4.2-2	Lateral Sweep of Sun's Path by Season (8 AM - 4 PM)	4.2-3
4.2-3	Horizontal Shadow Profile June 22 9:00 AM EDT	4.2-6
4.2-4	Horizontal Shadow Profile June 22 12:00 PM EDT	4.2-7

LIST OF FIGURES (Continued)

		Page
4.2-5	Horizontal Shadow Profile June 22 3:00 PM EDT	4.2-8
4.2-6	Horizontal Shadow Profile March 21 and September 23 9:00 AM EDT	4.2-9
4.2-7	Horizontal Shadow Profile March 21 and September 23 12:00 PM EDT	4.2-10
4.2-8	Horizontal Shadow Profile March 21 and September 23 3:00 PM EDT	4.2-11
4.2-9	Horizontal Shadow Profile December 22 9:00 AM EST	4.2-12
4.2-10	Horizontal Shadow Profile December 22 12:00 PM EST	4.2-13
4.2-11	Horizontal Shadow Profile December 22 3:00 PM EST	4.2-14
4.2-12	Horizontal Shadow Profile October 21 10:00 AM EDT	4.2-15
4.2-13	Horizontal Shadow Profile October 21 11:00 AM EDT	4.2-16
4.2-14	Horizontal Shadow Profile October 21 12:00 PM EDT	4.2-17
4.2-15	Horizontal Shadow Profile October 21 1:00 PM EDT	4.2-18
4.2-16	Horizontal Shadow Profile October 21 2:00 PM EDT	4.2-19
4.2-17	Horizontal Shadow Profile November 21 10:00 AM EST	4.2-20
4.2-18	Horizontal Shadow Profile November 21 11:00 AM EST	4.2-21
4.2-19	Horizontal Shadow Profile November 21 12:00 PM EST	4.2-22
4.2-20	Horizontal Shadow Profile November 21 1:00 PM EST	4.2-23
4.2-21	Horizontal Shadow Profile November 21 2:00 PM EST	4.2-24

LIST OF FIGURES (Continued)

		Page
4.3-1	"Fish eye" Base Map	4.3-2
4.3-2	Proposed Project Site	4.3-3
4.3-3	Existing Project Site	4.3-4
4.3-4	North Elevation of Proposed 125 Summer Street Project	4.3-5
4.3-5	East Elevation of Proposed 125 Summer Street Project	4.3-6
4.3-6	South Elevation of Proposed 125 Summer Street Project	4.3-7
4.3-7	West Elevation of Proposed 125 Summer Street Project	4.3-8
4.3-8	125 Summer Street - North Elevation	4.3-19
4.3-9	Existing Buildings - North Elevation	4.3-20
4.3-10	125 Summer Street - East Elevation	4.3-21
4.3-11	Existing Buildings - East Elevation	4.3-22
4.3-12	125 Summer Street - South Elevation	4.3-23
4.3-13	Existing Buildings - South Elevation	4.3-24
4.3-14	125 Summer Street - West Elevation	4.3-26
4.3-15	Existing Buildings - West Elevation	4.3-27
4.4-1	Site Location and Study Intersections	4.4-3
4.4-2	Study Area Circulation	4.4-5
4.4-3	Existing AM Peak Hour Traffic Volumes	4.4-6
4.4-4	Existing PM Peak Hour Traffic Volumes	4.4-6
4.4-5	Existing AM Peak Hour Pedestrian Flows	4.4-8
4.4-6	Existing PM Peak Hour Pedestrian Flows	4.4-8
4.4-7	Location of Public Transportation	4.4-9
4.4-8	Trip Distribution Map	4.4-19
4.4-9	1989 No-Build AM Peak Hour Traffic Volumes	4.4-20
4.4-10	1989 No-Build PM Peak Hour Traffic Volumes	4.4-20
4.4-11	1989 Build AM Peak Hour Traffic Volumes	4.4-20

LIST OF FIGURES (Continued)

		Page
4.4-12	1989 Build PM Peak Hour Traffic Volumes	4.4-20
4.4-13	Intersection Level of Service	4.4-23
4.4-14	1989 AM Peak Hour Pedestrian Flows	4.4-33
4.4-15	1989 PM Peak Hour Pedestrian Flows	4.4-33
4.5-1	Atlantic Avenue/Summer Street	4.5-6
4.5-2	Congress Street/Atlantic Avenue	4.5-7
4.5-3	Essex Street/Lincoln Street/Surface Artery	4.5-8
4.5-4	Kneeland Avenue/Surface Artery	4.5-9
4.5-5	Surface Artery/South Street	4.5-10
4.6-1	Typical Construction Equipment Noise Ranges	4.6-2
4.8-1	Sewer System at 125 Summer Street Site	4.8-2
4.8-2	Typical Combined Sewer System	4.8-3
4.8-3	Existing Water System at 125 Summer Street Site	4.8-11
4.10-1	Location of Test Borings	4.10-4

LIST OF TABLES

4.1-1	Representation of Scales	4.1-4
4.1-2	125 Summer Street No-Build Mean Wind Speeds (mph) Exceeded by Frequency of Occurrence	4.1-43
4.1-3	125 Summer Street Build Mean Wind Speeds (mph) Exceeded in Terms of Frequency of Occurrence	4.1-44
4.1-4	125 Summer Street No-Build Gust Wind Speeds (mph) Exceeded in Terms of Frequency of Occurrence	4.1-45

LIST OF TABLES (Continued)

		Page
4.1-5	125 Summer Street Build Gust Wind Speeds (mph) Exceeded in Terms of Frequency of Occurrence	4.1-46
4.1-6	125 Summer Street Gust Wind Speeds Exceeded 1% of the Time Ordered in Terms of Present Importance	4.1-47
4.1-7	125 Summer Street Mean Wind Speeds Exceeded 1% of the Time Ordered in Terms of Present Importance	4.1-50
4.3-1	Daylight Study Locations 125 Summer Street - North Elevation	4.3-9
4.3-2	Daylight Study Parameters 125 Summer Street - East Elevation	4.3-10
4.3-3	Daylight Study Parameters 125 Summer Street - South Elevation	4.3-11
4.3-4	Daylight Study Parameters 125 Summer Street - West Elevation	4.3-12
4.3-5	Daylight Study Parameters Existing Buildings - North Elevation	4.3-13
4.3-6	Daylight Study Parameters Existing Buildings - East Elevation	4.3-14
4.3-7	Daylight Study Parameters Existing Building - South Elevation	4.3-15
4.3-8	Daylight Study Parameters Existing Building - West Elevation	4.3-16
4.3-9	Percent Daylight Blocked	4.3-18
4.4-1	Proposed Development	4.4-3
4.4-2	Existing Pedestrian Volumes Along Summer Street	4.4-9
4.4-3	Existing Rapid Transit Line Capacity	4.4-11
4.4-4	Existing Rapid Transit Ridership	4.4-12
4.4-5	Daily Person-Trips	4.4-15
4.4-6	Mode Split	4.4-16
4.4-7	Vehicle Occupancy Factors	4.4-16

LIST OF TABLES (Continued)

		Page
4.4-8	Daily Vehicle-Trips	4.4-17
4.4-9	Percentages of Daily Trips During Peak Hours by Type and Direction	4.4-18
4.4-10	Project Peak Hour Trips by Mode	4.4-18
4.4-11	Trip Distribution	4.4-19
4.4-12	1989 Background Development	4.4-21
4.4-13	Level of Service Criteria for Signalized Intersections	4.4-23
4.4-14	Level of Service Criteria for Unsignalized Intersections	4.4-25
4.4-15	Intersection Level of Service Summary	4.4-23
4.4-16	Assignment of Rapid Transit Trips	4.4-30
4.4-17	Transit Volumes and Capacities	4.4-31
4.4-18	Summer Street Pedestrian Volumes	4.4-33
4.4-19	Access Goals	4.4-47
4.4-20	Effects of Access Plan Goals on Volume-to-Capacity Ratios	4.4-48
4.5-1	Intersection Analysis: Maximum Predicted CO Impacts (PPM)	4.5-11
4.5-2	Parking Garage Analysis: Maximum Predicted CO Impacts (PPM)	4.5-13
4.5-3	Dewey Square Tunnel Ventilation Buildings: Maximum Predicted CO Impacts (PPM)	4.5-14
4.5-4	Cumulative Maximum Predicted CO Impacts (PPM)	4.5-16
4.6-1	Average Noise Levels at Construction Sites	4.6-3
4.6-2	City of Boston Summary of Restriction or Construction Site Noise	4.6-6
4.9-1	125 Summer Street Estimated Electrical Consumption	4.9-4

PREFACE

PREFACE

This Final Environmental Impact Assessment (FEIA) provides detailed environmental studies on a new 22-story office building at 125 Summer Street in Boston. The scope of these environmental studies was required by the Boston Redevelopment Authority (BRA) in its Development Review Procedures and a specific Scope of Environmental Studies issued by the BRA staff on March 6, 1986 (reprinted in Section 2). Preceding this FEIA, the project proponent submitted a Draft Environmental Impact Assessment on May 23, 1986 and a Supplemental Draft Environmental Impact Assessment on June 13, 1986. (Both documents are referred to as the DEIA.) The FEIA is a reissuance of the entire DEIA, with changes, comments, and responses arising from the BRA review (see Section 2.1).

The next section of this FEIA provides an Executive Summary which briefly describes the major findings of each of the environmental studies. The reader will get an overview of the proposed project as well as a general understanding of the environmental issues, potential for impact and proposed mitigation measures. For more detailed descriptions, technical information, and methodologies, the reader is referred to the complete studies and appendices herein.

Following the Executive Summary, Section 2.0 provides the BRA's required scope, comments on the DEIR, and the proponent's responses to the comments. Section 3.0 provides the Project Description, and Section 4.0 includes all the required environmental imact studies.

The project proponent is A.W. Perry, Inc./Jaymont (U.S.A) Inc. Joint Venture. This report was prepared by HMM Associates. Traffic analysis was prepared by Vanasse/Hangen; wind impact analysis was prepared by Dr. George Succi; and historic resource analysis was prepared by Architectural Conservation Trust for Massachusetts. Elevation drawings, photographs for the model and existing conditions were provided by Kohn, Pederson Fox Associates.

1. SUMMARY

1. SUMMARY

The proposed development at 125 Summer Street is a new 22-story office building that will be built in the middle of a city-block bounded by Summer Street, South Street, the Surface Artery and Lincoln Street. Several 19th century buildings that now occupy the site will be retained and restored to form part of the base of the new building. The building will be used primarily for office use and will include street level specialty retail, restaurants and an interior gallery.

This report is the Final Environmental Impact Assessment (FEIA) that is required by the Boston Redevelopment Authority (BRA) under its Development Review procedures. The BRA required that the project proponent provide detailed studies on 10 subjects that may have potential for environmental impact. These are:

- Pedestrian-level wind
- Shadow
- Daylight
- Transportation
- Air Quality
- Noise
- Historic Resources
- Utilities
- Energy
- Natural Resources

While detailed studies are contained in this report, this section provides summaries of each subject's major findings.

The FEIA begins with a description of the project itself, including pertinent facts relating to the building's size and use. The site comprises approximately 31,034 square feet and is presently occupied by nine vacant buildings and a 70-foot ventilation stack over the Central Artery. The project is

located in the financial center which has been undergoing redevelopment recently with high-rise buildings and restoration of existing structures.

The proposed project consists of a 300-foot office building with 22 stories and 6 levels of underground parking. In scale and massing, the new building is designed to be compatible with the context of recent buildings under construction in the area and the historic character of the financial district. Its height will be less than the nearby 100 Summer Street, One Financial Center, and 101 Federal Street. Its distinctive architectural style and varied exterior treatments will be more reminiscent of 19th century buildings rather than modern glass, concrete and steel styles. This style is reinforced by the retention of four of the nine 19th century buildings which will be integrated into the overall project. The building's L-shaped configuration and vertical panels, window treatment, stone exterior and corner towers with vaulted spaces will combine to provide a varied and interesting treatment of the building's exterior. The design is in keeping with the historic setting and will maintain the existing fabric and rhythm of the financial district.

The building will be comprised of the main 22-story structure over a 5-story base which connects the existing 19th-century buildings into a unified structure. The latter will form a pedestal at the first 5 stories while the main building will be set back in the middle of the parcel. This configuration will have the effect of reducing apparent mass, preserve more daylight observed at street level, and reduce wind impacts (as will be described later).

The building will be used primarily for office space and will include street level retail. The interior of the base building will also have a gallery that will connect the building's side entrances from Lincoln to South Streets. The gallery will also contain retail uses. These retail uses will primarily be specialty shops, convenient stores, and restaurants that would appeal to office workers in the building and nearby buildings in the financial district.

Pedestrial-Level Wind Impact

The wind study is intended to predict the new building's effect on pedestrian level wind patterns in the area. The study methodology includes a scale model of the site and immediate surroundings. The model is subjected to wind tunnel testing, both for existing conditions and with the new building in place.

In studying existing wind patterns, the testing shows that 100 Summer Street opposite the project site to the north has the greatest effect on wind patterns in the area. Other nearby high-rise buildings such as One Financial Center, 99 Summer Street, and Fiduciary Trust also have noticeable effects on winds in and around the project area. Thus, the existing area around the project site is fairly windy, particularly in the vicinity of 100 Summer Street.

The addition of 125 Summer Street's proposed new building appears to affect winds at streets and pedestrian ways directly adjacent to the project site. The new building has a positive effect on winds by providing shelter on Summer Street when winds are from a southerly direction.

Analysis indicates that there are eight locations where gust velocities exceed the BRA threshold of 31 mph. It should be noted that seven of these eight locations exceed the BRA threshold even without the proposed new building.

With the construction of the 125 Summer Street building, wind speed would be reduced at five locations but increased at two locations. Mitigative measures that will be enforced at the site are detailed in Section 4.1.5.5.

Shadow Impact

The purpose of the shadow study is to predict the extent of new shadows resulting from the new building on sensitive areas such as parks, plazas, and pedestrian walkways. Nineteen shadow diagrams were compiled depicting net new shadows for various

times throughout the four seasons. Existing shadows were also compiled to determine new shadows associated with the proposed new bulding.

In general, shadow diagrams demonstrate that the majority of net new shadow generated at pedestrian levels as a result of the proposed building, are limited to streets adjacent to the project and some rooftops away from the project site. Most noticeable impacts are anticipated during late spring and early fall.

Additional shading of the 100 Summer Street Plaza is expected. This would be anticipated for any proposed building at the project site greater than the height of the existing buildings.

Daylight Impact

The purpose of this study is to determine the amount of perceived daylight at street level as a result of the introduction of the project.

A "fish eye" view of the project is taken from ground level at the center of an adjacent city street. This methodology involves mapping the project's base, setbacks, corners and other features to a base map using lateral and elevation angles.

The existing conditions already include the 19th century buildings which partially obstruct perceived daylight from adjacent sidewalks. With the main 22-story structure, there will be additional obstructions although these are minimized due to the buildings set back on the block.

Conclusions of the daylight study indicate that from the north elevation, an additional 21% of daylight would be blocked, from the east, an additional 9.5%, from the south, an additional 35.5%, and from the west elevation, an additional 11.5% daylight blockage.

Transportation Impact

This section describes the existing traffic-related conditions, estimates the impact of the development in terms of vehicle transit and pedestrian trips to the site, and provides an analysis of the study area under existing and future (1989) conditions.

Between 1985 and 1989, transit use is expected to increase by 25% based on background growth in the Downtown area. Current and planned improvements to the transit system will result in a substantial increase in transit capacity. The area is well served by bus and commuter rail is easily accessible from the project site. Parking in the area is at or near capacity.

Some parking will be available in the underground garage but overall the Access Plan identifies actions to take steps to mitigate project impact to transportation. These include actions to reduce and better manage vehicular trip generation to the site and to design access to the building in order to minimize impacts on adjacent streets. These measures include the promotion of ridesharing and transit use, the encouragement of alternative work schedules, the restriction of truck deliveries to non-peak hours, and the provision of administrative support for these efforts.

Overall, additional vehicular trips associated with the project are estimated at 1,230 (both ways) per day. Additional pedestrian and transit trips would be approximately 894 per day.

Air Quality Impact

The proposed project will attract motor vehicles that emit pollutants regulated by state and federal standards. Studies of project-generated emissions indicate contributions to existing violations of ambient air quality standards. Following mitigation considerations, however, pollutant levels should decrease.

Overall, the air quality analyses predicts improvements in future air quality, as a result of the increased effectiveness of vehicular emissions controls, despite modest increases in local traffic.

Noise Impact

This study is intended to determine the construction impact of noise on persons who live and work in the surrounding area and on passing motorists and pedestrians in the project area.

Average noise levels are highest during excavation and clean-up, assuming that all pertinent equipment is being utilized. Annoying noise levels may be experienced by pedestrians as they pass by or linger around the job site. Persons inside nearby buildings should not be significantly affected.

With the use of mitigative measures, such as the use of appropriate mufflers, turning off idling equipment, installing enclosures around the work area where stationary equipment is being used, and coordinating equipment operations to coincide with times of highest ambient noise levels, a reduction in construction noise impact can be achieved.

Historic Quality Impacts

Prior to construction of the Central Artery, the project area was part of a large block of row buildings that extended without interruption southward toward Essex Street.

The project site itself consists of nine commercial buildings. All buildings within the project area have been surveyed by the Boston Landmarks Commission. None have been classified as either Category I (Highest Significance), or Category II (Major Significance). Buildings at 115-117, 131-135, and 137-139 Summer Street are noted as Category III (Significant) buildings.

The construction of the project will include the demolition of five of the nine buildings. The four remaining structures will be retained and incorporated into the design.

Various aspects of the project have been planned to mitigate the effect of new construction on historic resources, such as the retention and restoration of some of the buildings and construction considerations to enhance existing structures.

Utility Impacts

The existing sewer system is operated by the Boston Water and Sewer Commission (BWSC). The present water system serving the site includes the East Side Interceptor, Boston Main Interceptor, MDC Columbus Park Connector, MDC Columbus Park Headworks MWRA Tunnel, and the Deer Island Treatment Plant. Predicted use of water and projected discharge of sewerage and solid waste are summarized as follows:

- Water -- Net new use of water (new less previous use) as a result of construction will be on the range of 25,000 to 30,000 gallons per day (GPD). Estimated daily flow from the public water supply is 80,000 GPD. The larger number is due to evaporation from heating, ventilation and air conditioning and other mechanical systems.

- Sewer -- The net discharge of 25,000 to 30,000 GPD will not be a burden on existing local sewer systems. However, due to existing capacity deficiencies of the East Side Interceptor, a retention tank will be designed to hold an entire day's generation of sanitary waste with a time release for discharge into the sewer system during periods of low tide.

- Solid Waste -- Estimated production of solid waste from the proposed building is 2 tons per day (TPD).

Energy Impacts

Attention to energy efficiency has been considered throughout the design of the project. The latest technology will be incorporated into the building which will minimize its energy demands. These include energy efficient windows, good insulation, an all-electric system with an emergency backup generator and space lighting. The total energy demand is projected to be 3,920,000 kilowatt hours.

The all-electric design exceeds accepted building codes and industry standards for energy efficiency.

Natural Resources Impact

Data was collected to determine existing site conditions and subsurface conditions at the proposed building site.

- Site Conditions -- A number of below-grade structures and underground utilities are in the immediate vicinity of the site.

- Soil -- Test borings of the soil at the site reflect the effects of glaciation, the subsequent estuarine environment, and man-placed fill. Fill, clay then glacial till was encountered top to bottom in the boring readings. Bedrock was not encountered in any of the test borings.

- Groundwater -- Groundwater level readings in the observation wells range between El. 5.4 and El. 13.1. Excavation will extend 35 to 40 feet below the present groundwater levels.

- Construction -- The 22-story structure with 5 levels of below-grade parking will require excavation to 58 feet. The building will be supported on individual spread footings or a mat foundation. The use of a concrete diaphragm wall will provide a permanent system for full relief at hydrostatic pressure for the lowest level floor slab. The wall would be extended 10 to 15 feet below the lowest floor level to serve as a permanent seepage cutoff. All foundations will be designed to resist earthquake forces calculated in accordance with the Massachusetts Building Codes.

2. BRA REQUIRED SCOPE

BOSTON
REDEVELOPMENT
AUTHORITY

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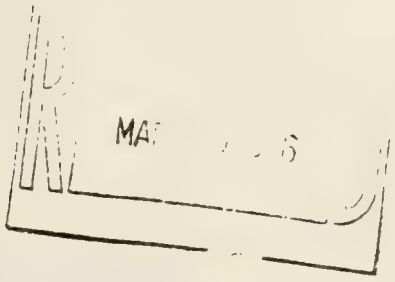

March 6, 1986

Mr. Joseph Fallon
Jaymont Properties
260 Franklin Street, Suite 2250
Boston, MA 02110

Dear Mr. Fallon:

As part of the Boston Redevelopment Authority's review of the Lincoln Block development, the Authority requires submission and approval of a comprehensive environmental impact report, as was discussed at your recent meeting with BRA staff.

The studies which are required for your proposal are listed on Attachment A and described in greater detail in the Authority's Development Review Procedures.

Prior to presentation of your proposal to the BRA Board, the environmental studies will be distributed to public agencies as well as interested groups and individuals for a 30-day public review period. Prior to the Authority's approval of contract documents, the environmental studies and any necessary mitigation measures must also meet with Authority approval.

Please work with my staff in coordinating the content and timing of the environmental report with the ongoing design review process.

We look forward to continuing our cooperative review with you during the coming months.

Sincerely,

Susan Allen
Assistant Director for
Development and Urban Design

C10/FF

ATTACHMENT A

LINCOLN BLOCK - REQUIRED ENVIRONMENTAL STUDIES

1. Pedestrian-level wind impact

   (a) Preliminary (qualitative) analysis to determine relative impacts and potential problem areas.

   (b) Wind tunnel testing (hot wire) of pedestrian and public areas (entrances, plazas) and of potential problem areas adjacent to and in the vicinity of the project site.

   (c) Identification of measures to mitigate impacts in areas where winds exceed acceptable levels.

   (d) Analysis should be presented as follows:

   - Present data for existing (no-build) and future build scenarios as follows:
     Mean velocity (exceeded 1% of time)
     Effective gust velocity (exceeded 1% of time)

   - Compare mean and effective gust wind speeds on both annual and seasonal basis, by wind direction.

   - Provide a written descriptive analysis of wind environment and impacts for each sensor point including such items as source of winds, direction, seasonal variations, etc., as applicable. Include analysis of suitability of location for various activities (e.g., walking, sitting, eating, etc.) as appropriate.

   - Provide maps of sensor locations with wind speed data, graphically indicating changes in wind speeds.

2. Shadow Impact

   The studies should distinguish additional and overlapping shadow caused by the project (net new shadow). Particular attention should be given to plazas, sidewalks, and other public open space areas.

   (a) Seasonal shadow studies at 9:00 A.M., 12:00 Noon, 3:00 P.M. for:

Summer solstice	22 June
Winter solstice	22 December
Spring/Fall equinoxes	21 March and 23 September

(b) Additional studies for: 10:00 A.M., 11:00 A.M., 12:00 Noon, 1:00 P.M., 2:00 P.M., for October 21 and November 21

3. Daylight Impact

(a) Daylight analysis of percentage of skydome obstructed by building

(b) Daylight analysis of no-build alternative

4. Transportation Impacts

(a) General

- o Project generation (daily and peak-hour).
- o Modal split.
- o Regional distribution and access

(b) Vehicular traffic

- o Circulation and access-impact on Central Artery and local street system and intersections.
- o Peak-hour travel demand (a.m. and p.m.).
- o Level-of-service analysis. (Coordinate with Central Artery, Dewey Square studies)

(c) Parking

- o Parking requirements.
- o Effect on parking supply/demand distribution in area.
- o Public/private use of parking spaces.

(d) Pedestrian circulation

- o Demand/capacity analysis (pedestrian densities).
- o Connections to public transportation stations/stops/terminals.

(e) Public transportation

- o Usage and capacity (rapid transit, bus, commuter rail).
- o Peak-hour demand/capacity.

(f) Truck service/deliveries and loading facilities

(g) Construction period impacts.

- o Parking requirements (workers, equipment, trucks).
- o Truck access routes.

5. Air Quality Impacts

(a) Impact on local air quality from additional traffic generated by the project (required if significant degradation of level of service at one or more intersections is identified).

(b) Emissions from parking garage and Central Artery vent shaft (potential pedestrian level air quality impacts).

(c) Construction related impacts (demolition, site preparation, construction activities; construction traffic and equipment); control and mitigation measures.

6. Noise Impacts

(a) Construction-related impacts (construction activities, equipment); control and mitigation measures.

7. Historic Quality Impacts

(a) Potential impacts on adjacent and nearby historic properties (Commercial Palace District, Bedford Building - compatibility, scale, materials).

(b) Reviews with Massachusetts Historical Commission, Boston Landmarks Commission, Preservation Alliance.

8. Utility Systems Impacts

(a) Water demand, sewerage/solid waste generation.

(b) Impact on water resources (supply/demand), disposal of wastes.

(c) Capacity and adequacy of existing utility systems serving project; BWSC requirements/

(d) Measures to conserve resources/recycling.

9. Energy Impacts

(a) Energy requirements and impact on resources and supply.

(b) Measures to conserve energy usage and fuel requirements.

(c) Feasibility of including solar energy provisions.

(d) Life-cycle costing analysis to determine efficient energy use.

10. Natural Resources Impact

(a) Analysis of sub-soil conditions.

(b) Description of excavation and foundation construction and potential impacts

N.B. IN ALL CASES WHERE ADVERSE IMPACTS ARE ANTICIPATED OR DETERMINED, MITIGATION MEASURES TO MINIMIZE OR AVOID THE ADVERSITY SHOULD BE IDENTIFIED.

2.1 COMMENTS ON DRAFT EIA

Since the submission of the DEIA documents in May and June, 1986, the BRA has received comments on several chapters. The BRA staff has also prepared its own comments. All of these comments are reprinted in this sub-section. The next sub-section contains the responses to the comments and how this FEIA addresses them.

BOSTON
REDEVELOPMENT
AUTHORITY

Raymond L. Flynn
Mayor

Stephen Coyle
Director

One City Hall Square
Boston, MA 02201
617 722-4300

July 31, 1986

Mr. Joseph F. Fallon
Senior Project Manager
Jaymont Properties
260 Franklin Street
Boston, MA 02110

Re: 125 Summer Street Office Building
Environmental Impact Assessment Report

Dear Mr. Fallon:

The BRA staff have reviewed the Draft Environmental Impact Assessment report and Supplement report which you have submitted for the 125 Summer Street Office Building project in downtown Boston. In accordance with the Authority's environmental review procedures, these documents also have been made available for public and agency review. Our comments on the reports are detailed below, and comments received by the Authority during the public review period are attached. The Final Environmental Impact Assessment should respond to these comments as well as provide the additional or corrected analyses as indicated.

General (Format)

The Final EIA must be submitted as a single document and is to include all the information and analyses required for the Draft document, as well as the Access Plan. Improvements in the graphics are encouraged; many are difficult to read and lack important elements (e.g. street names).

In addition, a summary of the Report and its findings, brief and understandable by the lay person, should be included in the Final report. This may be included as a separate section at the beginning of the report or as separate summaries at the beginning of each section.

The Final report also should include a copy of the Transportation Study scope, this letter and public comments on the draft reports.

Project Description

The Project Description section should be corrected to provide the most current information on the project (e.g. the tower is 22, not 23 stories, the site is 31,100 sq. ft. in area, etc.). Project drawings likewise should be updated to reflect changes in schematics, dated July 1986. The Final EIA

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should also describe in some detail the interior and exterior public improvements that are included in the project, indicating the types of retail shops to be provided in the project, the nature of street level interaction, and planned landscaping features.

Pedestrian Level Wind Impact

With regard to the discussion of "Wind Significance Criteria" (Section 4.1.3), although the 31 mph (not 31.5 mph as reported on page 4.1-45 and Appendix B-17) effective gust velocity threshold is the primary BRA standard for measuring wind acceptability, the BRA also makes use of the Melbourne Criteria for evaluating conditions with respect to types of activities (walking, sitting, etc.). The text should be revised to reflect this and should also list the criteria by type of activity.

The wind impact analysis indicates that there will be 8 (not 7, as reported on page 4.1-56) measurement locations where effective gust velocities are projected to exceed the BRA acceptability threshold of 31 mph. Seven of these eight locations also exceed the BRA threshold under the no-build condition. Although at five of these locations the wind is projected to be reduced with the 125 Summer Street building in place, wind speeds would be increased at two locations (11, 12) and would be increased from marginally acceptable to marginally unacceptable at Station 9 (the northwest corner of the project site). However, no mention of this exceedance is mentioned in the text. Notwithstanding the fact that winds are reduced at four of these locations with the project (but still exceed the BRA threshold), it is BRA policy that projects not result in exceedance of the 31 mph threshold. Therefore, the Final EIA must include a discussion of mitigation measures which could reduce winds to acceptable levels, at least at those locations where the project would increase already unacceptable levels or cause exceedances. Such mitigation is especially critical at Station 11 (100 Summer Street) which is a particularly dangerous area and where the project would increase the exceedance from 32.6 mph to 34.0 mph.

Some more specific points that require correction in the Final EIA include the following:

1. pg. 4.1-45 (¶2): The statement that there are only two locations where gust winds increase by more than 2 mph is incorrect. According to Table 4.1.5, increases of greater that 2 mph also occurred at locations 3, 6, 14, 29, and 5.

2. pg. 4.1-45 (¶3): Again, this paragraph is incorrect. Mean winds do not increase at station 25 (Table 4.1.7) but do (2 mph or more) at stations 14, 13, 8, and 29, as well as 7.

3. pg. 4.1-54 (Point 10): Since the BRA acceptability threshold is 31 mph, winds at this location with the building still are unacceptable.

4. pg. 4.1-54 (Point 27): Although winds are decreased at this location with the building, they are still unacceptable according to BRA criterion (mean speeds not exceeding 23 mph (see pg. 4.1-13).

5. pg. 4.1-55 (Point 25): According to Table 4.1.7, wind speeds at this point for No-Build and Build conditions are 28.5 and 28.1 mph respectively, not 28 and 27.2 mph, and thus are still unacceptable according to BRA criterion.

6. A map of the sensor locations with wind speed data, indicating the changes in wind speeds, should be included.

Shadow Impact

The shadow graphics are rather difficult to read and have not been reproduced very clearly. In addition, the impact of the Dewey Square tower is missing from the Oct. 21, 10:00 a.m. diagram and does not appear to be correctly shown on the Dec. 22, 9:00 a.m. diagram; in both these cases, the 125 Summer Street project might create no or minimal net new shadows on Summer Street. These deficiencies should be corrected in the Final EIA.

The order of the shadow diagrams should be coordinated with the discussion in the text.

Transportation Impacts

The Final EIA should explain clearly the determination of existing traffic volumes in relation to previous traffic studies in the same area. Existing traffic volumes apparently were obtained from the 1984 Dewey Square Comprehensive TSM Program study, revised (by actual counts?) to reflect the current one-way travel on Essex Street. However, many of the numbers are significantly different from the traffic volumes given in the International Place EIR, for instance, for the same intersections. What is the reason for this? Are different a.m. and p.m. peak time periods used? Are the 125 Summer Street volumes more (or less) current than International Place? It would seem to be appropriate that a uniform data base be used, updated as conditions change, and that these be clearly identified.

Questions have been raised during the review of the Draft EIA regarding the inclusion of growth outside the general downtown area into the traffic growth projections for 1989. The Final EIR should clarify whether traffic growth from such areas as the Back Bay and South Boston which would enter the downtown area was included in the background projections and any appropriate adjustments made to the analysis if necessary.

Four intersections show V/C ratios in excess of 1.00 for 1989 Build conditions, yet there is no real analysis of the impact of such congested conditions on the local street system (such as the occurrence of queuing and delays, the diversion of traffic, effect on adjacent intersections, or possible mitigation measures). The Final EIA should include a more detailed assessment of the impact of increased traffic due to the project development.

Two corrections should be noted in particular in page 1-4 of the Supplement. In the second paragraph, it is stated that in the evening peak hour the Congress Street intersections at Purchase Street and Atlantic Avenue decline from LOS "D" to "E", whereas Table 1-2 indicates a decline to an LOS of "F" The decline is particularly significant at Purchase Street. In addition, the analysis fails to indicate that the Surface Road/South Street/ Expressway Ramp intersection also will decline from LOS "D" to LOS "E" in the evening peak hour.

The effect on the intersections (LOS) if the Access Plan goals are fulfilled should be included in the analysis as a mitigation impact.

The pedestrian analysis should discuss or quantify the impact of the project on pedestrian flows given that Dewey Square already has high pedestrian volumes (5,500-6,000 crossings at peak hours), a demand/capacity impact analysis should be included in the Final EIA.

In Table 4.4.16 there appears to be a discrepancy between the 851 p.m. peak pedestrian trips along Summer Street projected in this table and the p.m. peak pedestrian trips (transit/walk) of 928 given in Table 4.4.9, the vast majority of which would probably use at least some part of Summer Street. An explanation is needed.

Concern also has been raised concerning the quality of the transit analysis which, based on a full-day demand/capacity analysis, appears to indicate excess capacity available and hence no problems. The real world situation, particularly at peak hours, is quite different. The transit analysis should be revised to reflect actual conditions at peak hours and the real impact of the project-generated peak hour trips on the existing transit system.

There is also a significant discrepancy in the number of PM peak hour transit trips generated by the project - Table 4.4.9 gives 898 trips whereas Table 4.4.14 in the transit analyses section gives only 626. This discrepancy needs to be corrected or explained adequately.

With regard to parking, the Draft EIA indicated a shortfall of 62 long-term spaces and 95 short-term spaces. The Final EIA should describe where parking demand surplus would go or what the impact would be on adjacent areas, particularly Chinatown.

The Final EIA and Access Plan should also address the need for short-term parking. In addition, the location of potential off-street parking during construction should be described.

Maps indicating LOS at the studied intersections and pedestrian volumes would be useful for reference and should be included in the Final EIA.

Air Quality Analysis

The air quality analysis of the Draft EIR was reviewed by both the Department of Environmental Quality Engineering and by a consultant (Tech Environmental, Inc.) under contract to the BRA. Their reports are attached. As discussed at a recent meeting of your consultants, the BRA and DEQE, a revision of the air quality analysis will be required for the Final EIA. Prior to the

re-analysis, the methodology, assumptions, receptor locations and other input data should be reviewed with DEQE and the BRA should be notified when this meeting is scheduled.

In addition, the air quality analyses includes minimal discussion of the large violations of the carbon monoxide standards that are predicted, fails to demonstrate consistency with the Massachusetts State Implementation Plan, and fails to show that the project will not interfere with the attainment and maintenance of the standards. Even though existing and 1989 no-build conditions are projected to exceed standards, the project itself will increase the violations. No measures to fully mitigate the increase are suggested. This failure must be corrected in the Final EIA, in consultation with DEQE.

Although a number of measures to mitigate dust emissions during construction are identified in the report, a strong commitment to the implementation of these measures and monitoring of compliance will be required.

Historic Quality Impacts

The Final EIA should include a discussion of reviews of the project with the Massachusetts Historical Commission, Boston Landmarks Commission, and Preservation Alliance.

On page 4.7-2, it is stated that no buildings on the site have been classified by the Boston Landmarks Commission as being in categories I, II, or III. However, the BLC's Central Business District Preservation Survey clearly lists 115-117, 131-135, and 137-139 Summer Street as Category III (Significant) buildings. This should be corrected in the Final EIA.

On page 4.7-6 (#7), the Great Fire occurred in 1872, not 1972.

As you are aware, the approval of this project is contingent upon submission of a satisfactory Final EIA for public review as well as a commitment to mitigation measures the Authority deems necessary to minimize adverse environmental effects identified in this environmental review process.

I thank you for your cooperation and look forward to the receipt of the Final document.

Sincerely,

Stephen Coyle
Director

JB3/DD/072886/5

The Commonwealth of Massachusetts
Executive Office of Environmental Affairs
100 Cambridge Street
Boston, Massachusetts 02202

MICHAEL S. DUKAKIS
GOVERNOR

JAMES S. HOYTE
SECRETARY

July 7, 1986

Ms. Susan Allen, Assistant Director
Development and Urban Design
Boston Redevelopment Authority
One Center Plaza
Boston, MA 02201

Dear Ms. Allen,

Thank you for the opportunity to comment on the EIR for 125 Summer Street. My comments are exceedingly brief, but will I hope be useful.

Process. I hope that as the BRA analyzes this EIR it will draw conclusions about refining the review process in the future. A better-defined review process would enhance the quality of public and agency input into ongoing BRA reviews with, I believe, commensurate benefits to the quality of the projects which emerge from those reviews. The most evident needs at this point are for (i) input into the Scoping process, and (ii) a requirement that there be public and reviewbable responses to comments on the Draft EIR.

Design. I think future EIRs should elaborate on the design concepts embodied in projects and explain the evolution of the project through the design process. It is self-evident that design decisions made by BRA and project proponents can have enormous visual impacts on Boston and its citizens, as well has major impacts on its historic fabric. EIRs have rarely been successful in coming to grips with these issues, but that does not mean that the task should not be attempted.

The onset of a Civic Design Commission will be a welcome addition to BRA design review processes. The BRA and the Commission, however, should not assume that design issues stand outside of and have no bearing on environmental impact issues. While they are not coterminous, they are intimately related, and the public that takes the trouble to review an EIR should have an opportunity to understand and appreciate the design decisions which are being made.

Sincerely,

Steven C. Dawe, for
Samuel G. Mygatt,
Assistant Secretary
Environmental Impact Review

SGM/sd

Boston

Raymond L. Flynn, Mayor

DATE: July 15, 1986

TO: Richard Mertens, BRA

FROM: Richard Dimino, Commissioner of Transportation

RE: 125 Summer St. Environmental Impact Assessment

We have reviewed the document referenced above. On the whole we find that it adequately describes the impact of the project on the immediately surrounding transportation facilities. We are particularly pleased with the developer's cooperativeness in the process of developing an Access Plan. A separate document using much of the transportation information included in this Assessment will serve as the City's first formal example of an Access Plan.

The developer and primary contractor have met with members of this department's construction management team, and have submitted a construction impacts mitigation proposal which the department is currently reviewing. Our preliminary judgement is that the proposal is substantially satisfactory and will require only minor changes.

This department is currently reviewing the draft Access Plan.

Richard A. Dimino, Commissioner, Traffic and Parking
City of Boston/City Hall Square/Boston, MA 02201

191 Hamilton Street
Cambridge, Mass. 02139
June 16, 1986

COMMENTS ON PROPOSED 125 SUMMER STREET OFFICE BUILDING

("ENVIRONMENTAL IMPACT ASSESSMENT" for BRA May 1986)

To : Boston Redevelopment Authority : attn. Susan Allen

From : Stephen H. Kaiser
Traffic and Transportation Engineer

The "Environmental Impact Assessment" for the 125 Summer Street Office Building is in some ways an improvement over earlier versions of environmental studies done for the City, such as the unscoped "EIR" for Chiofaro's International Place and the "EIR" for 500 Boylston Street, with its scope prepared by the consultant.

Unfortunately, there are still some rough edges. Who is this document prepared for : the BRA or the developers Perry/Jaymont? The scope was issued under the name of the BRA on March 6, 1986, and the report is dated May 23, 1986, which would be a very fast turnaround time to do wind and traffic studies. The report refers to Dewey Square measurements in 1985 by HMM and to transit growth between 1985 and 1989, which suggests that much of the preparatory work for the report was done in 1985, before the BRA scope was issued. How much of an improvement is it over the 500 Boylston study to have the BRA issue a scope (without a specified study area) months after the consultant has begun assembling data and doing analyses, compared to the 500 Boylston Street case where the consultant writes the scope for BRA approval? How can the BRA, as the development advocate for the city, perform an objective and critical review of a report on a development project?

What happens to any comments which are received during the comment period? Is the proponent in any way obligated to respond, or can he ignore them? The 500 Boylston project went through a 2-step Draft/Final review which at least allowed for some formal response to comments. Is BRA working under any laws or regulations in requiring such environmental studies? If not, why not? At least under MEPA, developers know more or less what to expect, especially with regard to timing and legal findings.

The report does include extensive wind and shadow studies, but no traffic calculations. Why no traffic calculations? I looked for them in vain, until page 4.4-1 provided the explanation : "Two sections of the report were not able to be completed due to time constraints and will be submitted as supplementary material."

Would General Motors dare to try to sell a car that had no engine and claim that "we didn't have time to put the engine together"? Well, at least the Japanese wouldn't, and no one should be in the business of either submitting or accepting incomplete environmental studies. Suppose the wind analysts had decided that they didn't have enough computer time, so they were going to submit their wind results in some undefined "supplementary material"?

What were the time constraints which prevented the consultants from assembling a full traffic study? Were they imposed by the developers? By the BRA?

When I got to the point of realizing that the "environmental impact assessment" report contained no traffic capacity analysis, I considered not going any further with my review, in view of the clear evidence that the integrity of the public documentation process had been so severely violated. This is a very similar criticism which was raised during the Chiofaro and 500 Boylston Street projects. Law and integrity must come first. I see very little improvement so far in the BRA environmental review process.

==========

Since I have reviewed the present incomplete document in some detail, let me offer the following comments, which could be considered when the developer finds time to assemble a complete report for submission to the BRA.

========== ALTERNATIVES ==========

The nearby Dewey Square office tower is reportedly now about half full, after two years of advertising and searching for tenants. The building boom in the Greater Boston area has left the office market glutted. Enter Perry/Jaymont to propose .... another office building. Do we really need more office space in the downtown, given all that is proposed, all that is vacant and a transportation system (among other things) which is ill-equipped to deal with such growth?

Simple rehabilitation and low-rise infill of the existing buildings should have been an alternative, and the options should have been spelled out in the BRA scope and assessed for traffic/transit impacts in the report.

========== WIND ==========

The wind study appears to be done in complete isolation to any previous studies. Was the proponent aware that a wind study was done for the Dewey Square Office Tower ("One Financial Center)" in August 1980 by the Boundary Layer Wind Tunnel Laboratory of the University of Western Ontario? This report was part of the MEPA submission for EOEA #3810 and there was an overlapping area where similar points were measured for mean wind and gust speeds.

The 1980 study considered a "No Build" without the Dewey Sq. tower and a "Build Case" with mitigation (trees). The 125 Summer St. Report begins with the Dewey Square Build and then adds the new tower.

The first table below shows the mean wind speeds over one hour which are exceeded 1% of the time during the year :

WIND-TUNNEL PROJECTIONS OF MEAN WIND SPEEDS EXCEEDED 1% OF THE TIME

	MEASUREMENT LOCATION	DEWEY SQ. #3810 NO-BUILD	DEWEY SQ. #3810 BUILD	125 SUMMER ST. STUDY NO-BUILD	125 SUMMER ST. STUDY BUILD
#2	HIGH/SUMMER (NE Corner of site)	10.3	14.8	16.4	16.7
#4	SOUTH/PURCHASE (SE corner)	-	16.1	14.4	14.9
#11	100 Summer St. (SW corner) at Devonshire	-	-	[25.2]	[26.2]
#16	SUMMER & ATLANTIC at Dewey Sq. Tower NE	14.7	16.0	20.5	20.3
#17	SOUTH/ESSEX at Dewey Sq. Tower SW	15.3	20.8	24.5	24.1
#25	SUMMER/PURCHASE at Dewey Sq. Tower N	15.1	16.0	28.5	28.1
#26	SUMMER/PURCHASE Northeast corner	15.8	19.4	28.0	27.2
#27	SUMMER/PURCHASE, N. corner South of Fuduciary Trust	-	14.4	29.1	26.3
	AVERAGE :	16.8		23.1	22.5

The table below compares the estimated wind gust speeds which are exceeded 1% of the time :

WIND-TUNNEL PROJECTIONS OF GUST WIND SPEEDS EXCEEDED 1% OF THE TIME

	MEASUREMENT LOCATION	DEWEY SQ. #3810 NO-BUILD	DEWEY SQ. #3810 BUILD	125 SUMMER ST. STUDY NO-BUILD	125 SUMMER ST. STUDY BUILD
#2	HIGH/SUMMER (NE Corner of site)	16.2	22.1	26.5	26.1
#4	SOUTH/PURCHASE (SE corner)	-	22.9	22.8	22.2
#11	100 Summer St. (SW corner) at Devonshire	-	-	32.6	34.0
#16	SUMMER & ATLANTIC at Dewey Sq. Tower NE	22.2	21.5	30.6	30.5
#17	SOUTH/ESSEX at Dewey Sq. Tower SW	24.4	28.8	34.3	34.2
#25	SUMMER/PURCHASE at Dewey Sq. Tower N	22.2	21.5	37.3	36.9
#26	SUMMER/PURCHASE Northeast corner	21.9	26.9	37.8	37.2
#27	SUMMER/PURCHASE, N. corner South of Fuduciary Trust	-	21.9	38.1	35.4

The #3810 BUILD and 125 Summer NO-BUILD should be fairly comparable, but look at the difference in the wind speeds : a 37% increase in average wind speeds. This data would lead us to believe that with no new skyscrapers in the Dewey Square area there would be a 37% increase in wind speed, while the addition of the new tower at 125 Summer Street would reduce wind speeds by 3% at 7 locations. Critics might reasonably complain that this result is counter-intuitive. Others might be a little more blunt : it doesn't make any sense at all.

The wind study has such comforting conclusions : "the addition of the new building at 125 Summer Street has little net effect on local winds... In short, the project has little net effect on local wind environment." Such studies would tend to make us believe that tall buildings are not the cause of aggravated wind conditions for pedestrians. Everyone is reassured, and the developers get just what they want to hear.

How delicately the wind report discussed the wind conditions at the corner of 100 Summer Street, the "lollypop building." The reader would never know that the owner was compelled to install railings at the south west corner of the building so that pedestrians would have something to hang onto when the winds got too fierce. Reportedly, the building owner has been sued by pedestrians who had been blown about by the wind and injured, and in one case the lawyers took a look at a $10,000 claim and the local wind conditions and advised their client to pay. Several years ago, the Boston Globe carried a front page picture of a young woman in mid-air, having been blown off her feet at the corner of 100 Summer Street. It was a somewhat inelegant position from which to become a front page celebrity, and the Globe followed up with a personal interview the next day. Apparently, it was a predictably windy day, and the photo was no accident. The photographer went to the worst and windiest spot on a windy day to get his picture. A little bit of perseverence caught a secretary with her feet swooshed up in the air.

The southwest corner of 100 Summer Street is probably the worst pedestrian environment in the entire city. The installed railings for pedestrians are testimony to this fact, even on a quiet day. Somehow the wind gets channeled down to this corner and creates mayhem. The miracle is that people put up with it. $10,000 lawsuits? Maybe we need a few million dollar class action suits filed by aggrieved pedestrians challenging such atrocities against the walking environment. So far, nothing else has worked. If we're lucky, we may get a handrail, while the dust blows in our face and we hang on for dear life. Imagine what would happen if a driver in a car were picked up, blown around and dumped back to the ground with a jarring crash. The protests, the media coverage, the court-suits would be legendary. The problem seems to be that the pedestrians have no voice, no lobbying arm.

Who is the defender of the pedestrian's interests : the BRA, which seems to be the developer's advocate? The Transportation department which traditionally has focussed on vehicles and how to park them? A suggestion : let's get the wind consultant, the BRA and the traffic planners to all stand on the corner of 100 Summer Street on a windy day. Let them make wind measurements and observations at this site (which reportedly will have wind speeds increased by 1 MPH or 4% by the 125 Summer Street tower.) Let them dwell on the fact that the 125 Summer Report shows 5 locations which will have higher gust speeds than the corner of 100 Summer Street. If they have the courage to stay on this corner for more than a few minutes on a windy day, my hat's off to them. And I'd better go chase it.

Now here is the clincher : despite claims of 26 MPH mean wind speed and 34 MPH gust speeds, the 100 Summer Street location -- handrail and all -- is described in the report as "marginally acceptable" for both the Melbourne and BRA criteria. (However, this appears to be an error and the BRA criteria of 23.5 MPH is indeed exceeded at 5 locations). The report does not mention that the Melbourne Criteria of "Dangerous" applies to three locations in Dewey Square. The thought that anyone could calmly discuss the 100 Summer Street location as "marginally acceptable" by any rational criterion suggests that something is terribly wrong here.

The wind criteria appear to be on the high side and do not appear to be calibrated against actual sidewalk experience. The modeling is very complex and the BRA does not have the technical expertise to review the wind consultant's work. Neither does MEPA. The experts need to translate their results into a format which is more understandable to laymen. For example, increases in wind speed means much more horizontal force and instability affecting bipeds. A simple indication of speed increment or percentage difference may be misleading. Indeed, a wind speed increase from 1 mph to 2 mph may be far more acceptable than one from 27 mph to 28 mph. Someone has to think more clearly about these issues if we are to face up to a future Boston of many highrise buildings.

The Assessment report notes on page 4.1-56 that wind speeds of 29 mph were measured in the vicinity of 125 Summer. What would the model predict under similar prevailing wind conditions? This information should be used to calibrate the model.

========== TRANSIT ANALYSIS ==========

Transit analysis has now come full circle, geographically. The first EIR which was scoped for transit analysis was the Dewey Square tower (#3810), because the proponent claimed that 90% of the trips would be made by transit. When the Draft EIR came out, it set a pattern for many studies which followed, summarized as follows :

* Obtain a passenger count from the MBTA

* Idealize a line capacity based on scheduled train performance

* Calculate a V/C ratio or otherwise show that under either Build or No-Build conditions the transit system is running just fine.

* Everyone lives happily ever after, and no mitigation is required.

The MEPA experience with the effects of the 1980-81 MBTA fare increases showed that the Authority only had the vaguest sense of what its ridership was. Maybe taking more than one sample trip measurement supplied by the MBTA and instead trying to establish some sort of average in recent years (including a trend line) would be far more accurate and useful.

Transit capacity calculations are invariably based on using announced MBTA schedules, which may or may not be adhered to, even on days of rider counting. An alternate source is CTPS, which also has a history of idealizing capacity.

When EIR #3810, prepared by HMM, compared ridership with capacity, they produced V/C ratios of 0.58 to 0.63 on the Red Line in the peak hour, 0.31 to 0.51 on the Green Line and 0.75-0.78 on the Orange Line. At the same time, MBTA patrons from Quincy to Newton were getting on jammed transit cars. Either people got very much fatter all of a sudden, or there is something quite wrong with the V/C calculations.

The errors have been compounded by various consultants over the years, to claim that switching from 4-6 cars will increase capacity by 50% (only a 50% increase in cars will do that, and such long-term growth in not anticipated). Also, no allowance is made for uneven loading, train bunching, missed trips, and peak hour factors. All of these factors are known and measurable for roadway traffic, and the traffic engineers do a much better job of dealing with them. The transit capacity analysis which says in effect that "the Green Line is half empty!" flies in the face of the actual performance which real world MBTA riders have come to know only too well.

And all the consultants know it too, every last one of them. So why do they produce such reports saying the MBTA service is absolutely wonderful? Need I tell the story about the consultant who used to ride the Red Line to work until one day he rode all the way with his nose squished up against a door window and logically asked himself what he was doing there ... and thereafter drove to work? The tragedy of our traffic engineers is that they are the ones best positioned by training, experience and knowledge to produce reports which would provide quality assessments of transit service, operations and mitigation. Instead, they produce starry-eyed fictions about the Green Line being half empty in the peak hour. What a shame. What a lost opportunity.

Is there any evidence that the BRA is concerned about the quality of transit analyses? Would it know what a good study should look like? Would it know what to do if a good study was submitted? The Authority did not produce a distinguished analysis of the transit aspects of the 500 Boylston project.

==========

My strong recommendation to the BRA is not to set themselves up as a municipal environmental review agency until they have the skills and the procedures in place. Scopes must be tightly written, and there must be documented response to comments, alternatives, and mitigation. Reports must be complete, with proper traffic and traffic capacity analysis. The emphasis must be on quality planning and quality reports.

The community response to BRA performance over International Place and 500 Boylston Street does not tend to build up the credibility of the BRA. The next step should be to reject this incomplete report, set up some written regulatory procedures, rewrite the scope and require developers to submit complete, quality reports. Sounds simple but it is not. A lot of work is required, but it is a worthy goal.

Stephen H. Kaiser, PhD
Traffic and Transportation
Engineer

191 Hamilton Street
Cambridge, Mass. 02139
July 7, 1986

ADDITIONAL TRAFFIC AND AIR POLLUTION

COMMENTS ON PROPOSED 125 SUMMER STREET OFFICE BUILDING

("ENVIRONMENTAL IMPACT ASSESSMENT" for BRA May 1986)

To : Boston Redevelopment Authority : attn. Susan Allen

From : Stephen H. Kaiser
Traffic and Transportation Engineer

These comments are supplementary to my June 16 comments on the first part of the 125 Summer Street "Assessment" report. While the focus of my comments will be on traffic and air pollution studies, there is value in stepping back and taking a look at the overall project and its reports, as well as the health of the environmental review process.

While the "Environmental Impact Assessment" for the 125 Summer Street Office Building does include a BRA scope, the listing of items is somewhat brief and did not include a study area for traffic. In this way, the developer/ consultant has greater freedom to define a more convenient study area.

The scope did require a traffic analysis of "access-impact on Central Artery and local street system", yet the report includes only an analysis of intersections. Since the Central Artery is usually congested in both directions in the afternoon peak hour, one can understand why analysis of the Central Artery would be an embarrassingly unresolved issue to study. Why did the assessment report not cover Central Artery impacts as called for in the scope? Not enough time? No pressing desire? The only solution is to go back and evaluate Central Artery impacts, as required by the scope.

Because the study area was not specified, the Assessment Report looks at background growth only in the general downtown Boston area. This decision effectively says that traffic growth by 1989 from all of South Boston is zero. Any other development or background growth is also zero, which is peculiar, since the 500 Boylston Report (just as on example) showed development traffic heading towards the South Station area.

The supplementary report also does not cover demand/capacity analysis for pedestrians or connections to transit stations or operational parking issues. The Supplemental Report on "Transportation" is not complete, because other pieces of the transportation scope are included in the original Assessment Report. With the transportation issue so fragmented between the two reports, how can we tell whether or not the scope items were complied with? It does appear that haste makes waste and that some scope items were lost in the rush to get both the original report and the supplemental report submitted to the BRA. Who is responsible for Quality Control as part of the BRA planning process?

The transportation analysis overall is all to typical of modern inner city development studies :

1. Intersections are looked at in isolation, and perfect signal timing is assumed.

2. Discussion of key bottlenecks or congestion points (such as the Central Artery) are avoided if possible.

3. Future intersections show V/C ratios in excess of 1.00 (in this case 4 locations for 1989 PM Build), yet there is no discussion of queues, delays, diverted traffic, impacts on adjacent intersections, or possible mitigation. In other words, these is no discussion of what will actually happen with 1989 real world traffic when demand exceeds capacity. The matter is just dropped. It most definitely is not "assessed."

4. Whenever a parking shortfall is forecast, there is seldom discussion of where the parking demand surplus would go. With a parking shortfall of 150 cars at the 125 Summer site, where will these cars go?

5. Present and future transit operations are glowingly described as being well under capacity. Everything is sugar and cream. These calculations are achieved by estimating a system capacity which is far greater than the MBTA can currently deliver. In some traffic calculations (such as the 1.41 existing V/C at Dewey Square), the methods are unduly pessimistic ("conservative"). Virtually all transit studies -- including that for 125 Summer Street -- are based on starry-eyed optimism which no one should believe, especially those familiar with the realities of everyday MBTA service.

The 500 Boylston Report was in many ways far superior with regard to traffic and pedestrians, because it at least faced up to V/C ratios of 0.90 and above and explicitly sought mitigation. The 125 Summer report does not, even to the point of not assessing pedestrian impacts on the Summer/Lincoln/Bedford intersection, currently without a pedestrian phase.

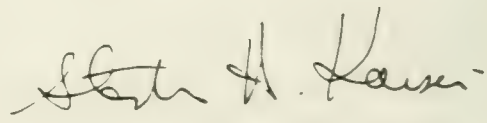
How does the BRA review such a fragmented report? I would urge that the city Transportation Department be closely involved in any review and writing of scopes, so that we can do a better job of producing quality assessment reports in a manner to defend the public interest.

AIR QUALITY

The quality of our air is a very important issue. The quality of our air pollution studies is also important, and on this matter I am on the side of the consultant and the developer.

The Assessment Report uses the "EPA Volume 9" method of calculating air pollution levels. One can ask a good question : how can any air pollution analysis method deal with V/C ratios of 1.25? The more fundamental issue is the failure of Volume 9 to yield credible results from the MEPA process. MEPA has switched over to the Caline-3 model, which may possibly be an improvement, but the record of accuracy in air pollution modeling is most uninspiring. The fact that air quality standards are violated, as the 125 Summer report claims, may be significant, but more probably it may not be -- against because of the poor track record of the air pollution model.

The goal of air pollution modeling (as with traffic, wind and others) is always to try to improve the state of the art. The constant repetition of air pollution modeling using Volume 9 without recognizing or trying to correct its errors is a waste of everyone's time. The developer should not be required to pay for this meaningless exercise, and the consultant should not be expected to sacrifice professional standards by going through any process which so clearly lacks both quality and a goal of quality improvement.



Stephen H. Kaiser, PhD
Traffic and Transportation
Engineer

Tech Environmental, Inc.
60 Birmingham Parkway, Boston, Massachusetts 02135
Phone: (617) 254-5283

July 8, 1986

RECEIVED
ENGINEERING
BOSTON REDEVELOPMENT AUTHORITY
JUL - 8 1986

Mr. William R. Barbato
Project Engineer
Boston Redevelopment Authority
1 City Hall Square
Boston, MA 02201

Re: Review of Air Quality Analysis for
125 Summer Street

Dear Bill:

As you requested, I have reviewed both the original EIA on this project dated May 23, 1986 as well as the Supplement dated June 13, 1986. My comments can be summarized as follows:

- The selection of analytical techniques and assumptions are inappropriate and out-of-date in some cases.
- In three areas, assumptions that are at odds with DEQE/EPA policy or data elsewhere in the EIA act to underestimate project impacts.
- The air quality analysis is curiously short on discussion of the large violations of the National Ambient Air Quality Standards that are predicted (page 2-18 of the Supplement), and fails to demonstrate that the development is consistent with the Massachusetts State Implementation Plan. Simply put, the analysis fails to show the project will not interfere with the attainment and maintenance of the standards for carbon monoxide (CO).

Selection of Study Intersections

The BRA Scope indicates air quality impacts from traffic generated by the project should be studied if significant degradation of Level of Service occurs. One intersection that was not studied is Summer Street/Atlantic Avenue (Dewey Square). This is undeniably the worst congested intersection near the project and is already over-capacity. The LOS analysis (page 1-4 of the Supplement shows project traffic will increase the V/C ratio from 1.10 to 1.16.

The project does not "degrade LOS" at this location only because traffic engineers assign all V/C values over 1.0 to category F. The traffic data suggest this intersection is likely to have the highest No-Build CO levels in the project area, and therefore any increase by the project will be more significant here than at other locations. Given that air quality standard violations are predicted at the Surface Artery/Essex Street/Lincoln Street intersection which has a better LOS than Dewey Square, you may want to consider whether the latter also warrants study.

Analytical Techniques

The analysis used three modeling procedures: MOBILE3 for emissions, GCA CO Hot Spot Guidelines for microscale impacts, and Halitsky's gas diffusion equations for garage exhaust impacts.

MOBILE3 is the correct choice for emissions modeling. The data input to this model are, however, a bit out-of-date. The analysis used a 1983 motor vehicle age distribution and a 15% stringency factor for I&M testing. DEQE has data available for 1985 on the motor vehicle age distributions and they have lowered the stringency factor to 13%. Some changes are good news, and these act to lower motor vehicle emission rates. A revised MOBILE3 computer run is enclosed and shows CO rates about 30% lower than those in the EIA Supplement.

The GCA Hot Spot Guidelines are a screening technique which are used to answer the question: does an intersection have the potential to violate CO standards? Given the number of EIRs filed on projects in the Dewey Square area and the latest CO data from Massachusetts DEQE that show continued violations of CO standards at their Essex Street monitor, sufficient data already existed to answer the question. The answer is yes. My point is that more refined modeling techniques should have been used from the start. Both DEQE[1] and EPA[2] Region I published policy guidance would argue for the type of refined microscale modeling that is commonly required by MEPA, particularly since this section of Boston is classified as a Nonattainment Area for CO.

---

[1]DEQE Division of Air Quality Control, "Indirect Source Guidelines", June 1984.

[2]EPA Region I, "EPA Region I Mobile Source Modeling Procedures", 1985.

The air quality results shown on page 2-18 of the Supplement simply say yes, there is potential to violate the standards. What is missing is the refined modeling analysis that will tell us where violations, if any, do and will occur. DEQE policy[1] states that for microscale analysis they "prefer CALINE-3, adapted for intersection analysis according to EPA guidance". This is the model that should have been used.

Halitsky's equations are appropriate for modeling garage emissions. The analysis fails to follow the BRA Scope, however, in examining the impacts from the Central Artery vent shaft. Vent shaft impacts are only calculated for receptor 2. They should also be added into the total concentrations at the other two receptors. In particular, receptor 3 is directly across the street from the vent shaft and has extremely high CO levels from just intersection impacts (page 2-18 of the Supplement).

Assumptions

Assumptions are made in three areas that I believe are at odds with DEQE/EPA policy or published data, and act to underestimate impacts. The first assumption is that full roadway capacity is available at the three intersections. In Appendix A of the Supplement, data from Vanasse/Hangen indicate heavy pedestrian movements during peak hour reduce roadway capacity by 20% at Essex St./Lincoln St./Surface Artery and South St./Surface Artery, and by 30% at Summer St./Lincoln St./Bedford St. The capacity reductions are real to anyone who drives this area at rush hour. I do not believe, based on the report's contents, that the air quality analysis accounted for these reductions in capacity. It should.

The second assumption is that 8-hour concentrations can be scaled from 1-hour concentrations by a factor of 0.33. This number is not recommended by either DEQE or EPA, and is contradicted by nearby DEQE monitoring data. DEQE recommends[3] a factor of 0.6 to 0.7, while EPA endorses[2] the value of 0.7. In addition, data from DEQE's Essex Street monitoring station[4] support the use of a factor that is 0.6. I doubt that the number of 0.33 used in the analysis was reviewed with either agency in advance.

---

[3] DEQE Division of Air Quality Control, "Technical Memorandum #2: Persistence Factors", 1982.

[4] DEQE Division of Air Quality Control, "1984 Air Quality Data Report", 1985.

The third assumption is that background levels of 5.0 ppm (1-hour) and 3.0 ppm (8-hour) are representative of the project area (page 2-4 of the Supplement). It is true that these numbers can be found in DEQE's background policy document. It is also true that recent CO monitoring data from DEQE's Essex Street station suggest even higher numbers may apply in this area of downtown Boston. And in fact, DEQE has required higher background levels for a study of air quality in the Washington Street/Kneeland Street corridor. It would strengthen this section of the report if the author quoted the person at DEQE who "determined" the background levels and the date of his communication with the agency.

Discussion of Results

Having predicted some unusually large violations of the CO standards (page 2-18), the analysis fails to properly interpret the numbers. First, as has been said before, impacts above standards from a screening model do not indicate a violation necessarily exists. They do say that refined modeling should be done to answer the question.

The results do not show, as claimed on page 2-17, that "the project is not the cause of an exceedance of the NAAQS at any receptor". It may very well be that 1989 No-Build 1-hour CO levels at receptor 3 from a refined analysis turn out to be 34 ppm, and the project, by adding 1.4 ppm, causes a violation by bringing the total over 35 ppm.

More importantly, any project that increases air pollution needs to be evaluated by the test DEQE would apply, namely does it interfere with the attainment or maintenance of standards? If there is already a violation of public health standards and a project adds another 1.4 ppm (page 2-17), it is interfering with efforts to attain the standards. In such a case, a developer needs to fully mitigate such an increase.

It may turn out that 125 Summer Street does not interfere with the State Implementation Plan to attain and maintain CO standards. The EIA and its Supplement though do not provide enough to reach that conclusion.

Please call if you have any questions about this review. I would also like to note that Tech Environmental can provide technical assistance to the BRA on other environmental topics. Thank you for the opportunity to serve the Boston Redevelopment Authority.

Sincerely,

TECH ENVIRONMENTAL, INC.

Peter H. Guldberg
Certified Consulting Meteorologist

PHG/ag

MOBILE3 - TECH ENVIRONMENTAL, INC

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1971
LAST MODEL YEAR COVERED:	1986
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR 1986 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0 ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPEEDS:	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	168.10	278.14	313.04	292.43	481.71	3.98	4.73	37.13	212.04	195.03

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0 ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPEEDS:	10.0	10.0	10.0		10.0	10.0	10.0	10.0	10.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	107.03	172.01	184.49	177.12	320.49	2.74	3.26	25.60	101.88	122.52

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS

CAL YEAR: 1986 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0 ALTITUDE: 500. FT

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	15.0	15.0	15.0		15.0	15.0	15.0	15.0	15.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	80.30	126.32	130.14	127.88	225.28	1.98	2.36	18.48	66.16	90.18

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS

I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0 ALTITUDE: 500. FT.

REGION: LOW

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26 0	
VMT MIX:	0.646	0.122	0.089		0.035	0.041	0.018	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	37.65	56.28	55.54	55 97	95.01	1.14	1.32	9.71	37.85	40.26

(3) TABLE 7 - PUBLIC SITES

1984 CARBON MONOXIDE MONITORING RESULTS

CO Units: mg/M^3

City	Saroad #	Instrument Method	Number of Hourly obs.	Max. 1 hr. obs.	2nd. Max. 1 hr.	Max. 8 hr. obs.	2nd. Max. 8 hr	# of 8 hr averages above 10
CENTRAL MASSACHUSETTS AIR QUALITY CONTROL REGION (118)								
Worcester	2640-020	11	8346	32	23	14	12	3
MERRIMACK VALLEY AIR QUALITY CONTROL REGION (121)								
Lowell	1080-007	11	7731	31	25	15	13	5
METROPOLITAN BOSTON AIR QUALITY CONTROL REGION (119)								
Boston	0240-002	11	8396	15	12	10	9	0
Boston	0240-015	11	7940	14	13	7	7	0
Boston	0240-021	11	8415	16	14	8	7	0
Boston	0240-022	11	8401	22	20	13	12	4
PIONEER VALLEY AIR QUALITY CONTROL REGION (042)								
Springfield	2160-007	11	8524	25	22	13	12	5
Springfield	2160-014	11	8523	16	12	8	7	0

Essex Street Station

$$\frac{\text{8-hour}}{\text{1-hour}} = \frac{13}{22} \simeq \frac{12}{20} = 0.6$$

** When total observations are less than 6,570, the sample cannot be guaranteed to contain the actual maximum concentration value for the year. An observation is a single hourly reading at a site. Carbon monoxide data are collected throughout the year; 100 percent data capture during this period represents 8,760 hourly observations.

Boston Water and Sewer Commission

10 Post Office Square
Boston, Massachusetts 02109
617-426-6046

June 23, 1986

Mr. Stephen Coyle, Director
Boston Redevelopment Authority
Boston City Hall
One City Hall Square
Boston, Massachusetts 02201

RE: 125 Summer Street-
Draft Environmental Assessment
Report

Dear Mr. Coyle:

In response to your letter dated May 27, 1986, the Boston Water and Sewer Commission has reviewed the above-referenced document and has the following comments:

1. The description of flow transport in the East Side and Boston Main Interceptors is either incorrect or needs to be updated.

2. Adequacy of Boston Water and Sewer Commission's water lines to supply the projected demands for this project is not addressed.

3. The stated average daily water usage (80,000 GPD) estimated for this Development appears excessive. Boston Water and Sewer Commission requests figures on the air conditioning water requirements.

The Boston Water and Sewer Commission's Engineering staff would be pleased to meet with the Project's proponent or representative to discuss these concerns.

Very truly yours,

Charles Button

Charles Button, P.E.
Chief Engineer

CB/JP
cc: Mr. Joseph Fallon - A.W. Perry, Inc./
Jaymont (U.S.A.), Inc.

2.2 RESPONSE TO COMMENTS ON DRAFT EIA

Following is a summary of comments on the DEIA and responses to each comment.

2.2.1 BRA LETTER

General Format

Comment -- "The Final EIA must be submitted as a single document and is to include all the information and analyses required for the Draft document, as well as the Access Plan. Improvements in the graphics are encouraged; many are difficult to read and lack important elements (e.g., street names)."

Response -- This FEIA document includes all the information and analyses required for the DEIA and a copy of the Access Plan is included in Section 4.4. Several maps and graphics from the DEIA which reproduced poorly were redrawn to improve quality in the FEIA.

Comment -- "In addition, a summary of the Report and its findings, brief and understandable by the lay person, should be included in the Final report. This may be included as a separate section at the beginning of each section."

Response -- A summary of the Final EIA, including findings, has been included as a separate section at the beginning of the report.

Comment -- "The Final report should include a copy of the Transportation Study scope, this letter and public comments on the draft reports."

Response -- A copy of the Transportation Study Scope has been included in the FEIA in Section 2.1.

Project Description

Comment -- "The Project Description section should be corrected to provide the most current information on the project (e.g., the tower is 22, not 23 stories, the site is 31,100 square feet in area, etc.). Project drawings likewise, should be updated to reflect changes in schematics, dated July 1986."

Response -- The FEIA has been updated to provide the most current information on the project, such as the number of stories of the proposed tower and the correct square footage of the area. Project schematics have been updated to reflect changes since the submittal of the DEIA.

Comment -- "The Final EIA should also describe in some detail the interior and exterior public improvements that are included in the project, indicating the types of retail shops to be provided in the project, the nature of street level interaction, and planned landscaping features."

Response -- The Project Description in the FEIA includes additional language to describe street level retail activity and planned landscaping features.

Pedestrian Level Wind Impact

Comment -- "With regard to the discussion of "Wind Significance Criteria" (Section 4.1.3), although the 31 mph (not 31.5 mph as reported on page 4.1-45 and Appendix B-17) effective gust velocity threshold is the primary BRA standard for measuring wind acceptability, the BRA also makes use of the Melbourne Criteria for evaluating conditions with respect to types of activities (walking, sitting, etc.). The text should be revised to reflect this and should also list the criteria by type of activity."

Response -- The text has been revised to include the Melbourne Criteria for evaluating conditions with respect to types of activities as well as the gust velocity threshold.

Comment -- "The wind impact analysis indicates that there will be 8 (not 7, as reported on page 4.1-56) measurement locations where effective gust velocities are projected to exceed the BRA acceptability threshold of 31 mph. Seven of these eight locations also exceed the BRA threshold under the No-Build condition. Although at five of these locations the wind is projected to be reduced with the 125 Summer Street building in place, wind speeds would be increased at two locations (11, 12) and would be increased from marginally acceptable to marginally unacceptable at Station 9 (the northwest corner of the project site). However, no mention of this exceedance is mentioned in the text. Notwithstanding, the fact that winds are reduced at four of these locations with the project (but still exceed the BRA threshold), it is BRA policy that projects not result in exceedance of the 31 mph threshold. Therefore, the Final EIA must include a discussion of mitigation measures which could reduce winds to acceptable levels, at least at those locations where the project would increase

already unacceptable levels or cause exceedances. Such mitigation is especially critical at Station 11 (100 Summer Street) which is a particularly dangerous area and where the project would increase the exceedance from 32.6 mph to 34.0 mph."

Response -- The text has been rewritten to correctly state the wind impact analyses. Mean annual winds as high as 29 mph were measured at locations near the 125 Summer Street site. Eight of the 29 measurement locations were deemed to be hot spots at which the winds exceeded the BRA gust velocity criteria of 31 mph one percent of the time. Seven of these eight locations also exceed the BRA threshold under the No-Build condition. At five of these locations, the wind is projected to be reduced with the 125 Summer Street building in place. Wind speeds are projected to be increased at two locations (11, 12) and would be increased from marginally acceptable to marginally unacceptable (Melbourne criteria) at station 9, the northwest corner of the project site.

At the three stations at which the wind velocity is increased, two stations were projected to increase by an amount smaller than the resolution of the test (1 mph). Only station 11 was projected to increase by an amount greater than the measurement resolution. A discussion of mitigating measures at this site is included in 4.1.5.5.

Figures 4.1-21 and 4.1-22 summarize the data for mean wind and gust winds exceeded one percent of the time.

Comment -- "Some more specific points that require correction in the Final EIA include the following:

1. Page 4.1-45 (Paragraph 2): The statement that there are only two locations where gust winds increase by more than 2 mph is incorrect. According to Table 4.1-5, increases of greater than 2 mph also occurred at locations 3, 6, 14, 29, and 5."

Response -- This statement was corrected to assure accuracy. Table 4.1-6 shows that there are several locations at which gust winds increased by more than 2 mph (points 3, 5, 6, 7, 14, 28, 29). At all these locations, the 1% gust velocities are less than 31.5 mph.

Comment

2. "Page 4.1-45 (Paragraph 3): Again, this paragraph is incorrect. Mean winds do not increase at station 25 (Table 4.1-7) but do (2 mph or more) at stations 14, 13, 8, and 29, as well as 7."

Response -- This paragraph was rewritten to correctly state wind conditions. Mean winds increase by more than 2 mph at four stations (7, 8, 14, 29). In all of these locations, the winds with 125 Summer Street never exceed 19 mph more than 1% of the time, i.e., the 1% mean speeds are all less than 19 mph. If we refer to Figure 4.1-20, we see that the Melbourne criteria indicate all these stations are acceptable for walking.

Comment

3. "Page 4.1-54 (Point 10): Since the BRA acceptability threshold is 31 mph, winds at this location with the building still are unacceptable."

Response -- Point 10 is at the apex of the intersection of Summer and West Bedford Streets. Here the highest levels are due to the north wind. The new building tends to lower the level due to the north wind and reduces the 1% gust levels by 1.2 mph. With the new building, this location exceeds the 1% annual gust level deemed unacceptable by the BRA by only 0.2 mph.

Comment

4. "Page 4.1-54 (Point 27): Although winds are decreased at this location with the building, they are still unacceptable according to BRA criterion (mean speeds not exceeding 23 mph (see pg. 4.1-13))."

Response -- Point 27 is at the south corner of the Fiduciary Trust Building. At present this location is dangerous. The new building reduces the winds at this location to the point of being marginally acceptable. According to the Melbourne Criteria although the winds are decreased at this location with the building, they are still unacceptable according to the BRA criterion (mean wind speeds not exceeding 23 mph). It is clear that the project does not leave an adverse impact, but rather it improves the situation.

Comment

5. "Page 4.1-55 (Point 25): According to Table 4.1-7, wind speeds at this point for No-Build and Build conditions are 28.5 and 28.1 mph, respectively, not 28 and 27.2 mph, and thus are still unacceptable according to BRA criterion."

Response -- Point 25 is at the north corner of Financial Center. At present, this location is dangerous. The new building reduces the wind from 28.5 mph to 28.1 mph. Again, an existing problem is mitigated by the project albeit not sufficiently to fall below the BRA criterion. However, the point is that the project has a beneficial impact in this regard.

Comment

6. "A map of the sensor locations with wind speed data, indicating the changes in wind speeds, should be included."

Response -- A map of the sensor locations with wind speed data, indicating the changes in wind speeds had been included in the Executive Summary but is now also in this FEIA on pages 4.1-57 and 4.1-58.

Shadow Impact

Comment -- "The shadow graphics are rather difficult to read and have not been reproduced very clearly. In addition, the impact of the Dewey Square tower is missing from the October 21, 10:00 AM diagram and does not appear to be correctly shown on the December 22, 9:00 AM diagram;

in both these cases, the 125 Summer Street project might create no or minimal net new shadows on Summer Street. These deficiencies should be coordinated with the discussion in the Final EIA.

The order of the shadow diagrams should be coordinated with the discussion in the text."

Response -- The BRA comment correctly notes that diagrams for October 21, 10:00 AM and December 22, 9:00 AM did not include the Dewey Square Tower. These diagrams were redrawn for this FEIA.

The order of the diagrams has also been changed to coincide with the shadow impact discussion in the text. Moreover, all diagrams were reproduced with greater clarity.

Transportation Impacts

Comment -- "The Final EIA should explain clearly the determination of existing traffic volumes in relation to previous traffic studies in the same area. Existing traffic volumes apparently were obtained from the 1984 Dewey Square Comprehensive TSM Program study, revised (by actual counts?) to reflect the current one-way travel on Essex Street. However, many of the numbers are significantly different from the traffic volumes given in the International Place EIR, for instance, for the same intersections. What is the reason for this? Are different AM and PM peak time periods used? Are the 125 Summer Street volumes more (or less) current than International Place? It would seem to be appropriate that a uniform data base be used, updated as conditions change, and that these be clearly identified."

Response -- The explanation of the development of the base network in the Final EIA has been expanded and clarified. In addition, the base networks themselves were reviewed for consistency with other downtown studies and, where appropriate, were modified. Most modifications are the result of making the networks consistent with the base networks being developed for another project at One Twenty Five High Street. The One Twenty Five High Street study area includes seven intersections in the 125 Summer Street study area and an additional ten intersections to the north and west. The One Twenty Five High Street networks are based on networks developed for 125 Summer Street, the Milk and Broad Street development, the Fan Pier and Pier 4 developments, and International Place. These data were supplemented with recent counts, principally along High and Purchase Streets. Generally, the current counts show lower approach volumes than those shown in the previously developed networks, most probably because of diversions associated with the extensive number of construction projects in the area.

As part of the review of the 125 Summer Street networks, volumes at five intersections were compared with International Place volumes. Of the ten cases compared (AM and PM peak hours for five intersections), eight had higher approach volumes for 125 Summer Street than for International Place. Of the two cases with lower volumes, one case involved only slightly lower volumes. The International Place volumes are based principally on counts taken in 1981 or earlier (as far back as 1976). In contrast, the 125 Summer Street volumes are based on projected 1987 networks developed for the Dewey Square study. Counts taken in spring 1986 at selected locations indicate that the Dewey Square volumes are probably most representative of travel patterns that would be expected in the area without diversions due to construction disruptions.

The High Street and Purchase Street intersections on Congress Street were modified on the AM peak hour network to achieve a balance with upstream locations (in the One Twenty Five High Street network) along Purchase Street, High Street and Congress Street and to correct an improperly posted volume for the eastbound right turn at Congress and Purchase Streets. On the PM peak hour network several locations were changed to provide better balance to upstream locations along Congress and Purchase Streets and to correct an imbalance on High Street between Federal Street and Congress Street. The removal of a parking garage on that block has resulted in decreased volumes along High Street at Federal Street and Summer Street. A fall 1986 count at the Summer Street/High Street/South Street location confirmed this reduction. The final network volumes at this location are actually higher than the count to account for possible diversions from High Street because of construction at International Place.

The adjustments to the base networks have also been made in the No-Build and Build networks. The level of service analysis found in the Probable Project Impacts section has been revised to reflect the network changes. Also, all necessary corrections to the text have been made to incorporate any changes in levels of service and volume-to-capacity ratio.

Comment -- "Questions have been raised during the review of the Draft EIA regarding the inclusion of growth outside the general downtown area into the traffic growth projections for 1989. The Final EIA should clarify whether traffic growth from such areas as the Back Bay and South Boston which would enter the downtown area was included in the background projections and any appropriate adjustments made to the analysis if necessary."

Response -- Limited amounts of traffic growth can be expected in the study area from Back Bay and South Boston by 1989. Peak hour impacts from Back Bay development will be limited to some outbound trips to the Callahan Tunnel. Inbound Sumner Tunnel trips in the moring would likely avoid downtown and use Tremont Street. Impacts from South Boston developments will be felt more directly downtown along Altantic Avenue. However, the bulk of South Boston development will be occupied after 1989 and, therefore, impacts in 1989 will be limited.

The limited impacts of Back Bay and South Boston development have previously been incorporated in the future networks because the existing base network was based on the 1987 projected Dewey Square network. This network included projections of growth from background developments which have materialized more slowly than anticipated. As a result the base volumes tend to overstate base conditions. This conservative (high) estimate was carried over to the No-Build networks and was assumed to account for the limited additional impacts anticipated from Back Bay and South Boston development.

Comment -- "Four intersections show V/C ratios in excess of 1.00 for 1989 Build conditions, yet there is no real analysis of the impact of such congested conditions on the local street system (such as the occurrence of queuing and delays, the diversion of traffic, effect on adjacent intersections, or possible mitigation measures). The Final EIA should include a more detailed assessment of the impact of increased traffic due to the project development."

Response -- The Final EIA provides a detailed assessment of project impacts at the intersections with V/C ratios in excess of 1.0 in the section entitled Capacity Analysis. The Access Plan also includes mitigation measures which might be taken at project impacted intersections to reduce V/C ratios in excess of 1.0. These measures appear in the section entitled Roadway Improvements.

Comment -- "Two corrections should be noted in particular in page 1-4 of the Supplement. In the second paragraph, it is stated that in the evening peak hour the Congress Street intersections at Purchase Street and Atlantic Avenue decline from LOS "D" to "E", whereas Table 1-2 indicates a decline to an LOS of "F". The decline is particularly significant at Purchase Street. In addition, the analysis fails to indicate that the Surface Road/South Street/ Expressway Ramp intersection also will decline from LOS "D" to LOS "E" in the evening peak hour."

Response -- The second paragraph has been rewritten to reflect the changes in level of service shown in Table 1-2 (now Table 4.4-15). The third paragraph indicates the decline in service at Surface Artery/South Street/ Expressway on-ramp from the No-Build to Build condition. There is no change in level of service at this location between existing and No-Build conditions and therefore no reference to the location in the second paragraph.

Comment -- "The effect on the intersections (LOS) if the Access Plan goals are fulfilled should be included in the analysis as a mitigation impact."

Response -- A discussion of the effect of Access Plan goals on intersection level of service has been added to the Access Goals section of the Access Plan.

Comment -- "The pedestrian analysis should discuss or quantify the impact of the project on pedestrian flows given that Dewey Square already has high pedestrian volumes (5,500-6,000 crossings at peak hours), a demand/capacity impact analysis should be included in the Final EIA."

Response -- Figures 4.4-14 and 4.4-15 have been added to the pedestrian analysis to show 1989 pedestrian volumes between the project site and Dewey Square with both background development and the project included. Also included is a level of service analysis on the south side of Summer Street between South Street and Surface Artery. This location was chosen for analysis because it will receive the maximum pedestrian impact in the Dewey Square area from the project.

Comment -- "In Table 4.4-16 there appears to be a discrepancy between the 851 PM peak pedestrian trips along Summer Street projected in this table and the PM peak pedestrian trips (transit/walk) of 928 given in Table 4.4-9, the vast majority of which would probably use at least some part of Summer Street. An explanation is needed."

Response -- The 851 PM peak hour project pedestrian trips shown in Table 4.4-16 (now Table 4.4-18) show only those trips which reach Washington Street or Dewey Square along Summer Street. These 851 trips represent almost 92 percent of all project generated walk and transit trips. The remaining eight percent, or 77 trips, use only a short portion of Summer Street near the site before turning onto other streets. Many of these trips represent commuter bus riders using Devonshire Street to reach the express bus stop in the Financial District. Table 4.4-9 is now Table 4.4-10.

Comment -- "Concern also has been raised concerning the quality of the transit analysis which, based on a full-day demand/capacity analysis, appears to indicate excess capacity available and hence no problems. The real world situation, particularly at peak hours, is quite different. The transit analysis should be revised to reflect actual conditions at peak hours and the real impact of the project-generated peak hour trips on the existing transit system."

Response -- The transit analysis presented in the draft assessment report is a peak hour analysis and all capacity and ridership figures are for the peak direction in the PM peak hour. The estimates of existing and projected line capacity for the Red and Green lines have been revised based on observations of actual operating conditions made in late September and early October 1986. On the basis of these observations the number of peak hour Red line trains through downtown has been reduced to 16 actual from 24 scheduled. Similarly, the number of Green line trains operating outbound west of Park Street in the evening peak hour has been reduced from 47 scheduled to 36 actual. For the Green line, revisions have also been made in the average number of cars per train and the capacity of each car. The car capacity of 130 persons is a generalized planning figure used by the MBTA. The actual physical capacity is higher and loads heavier than the planning capacity were frequently observed.

The text and tables (Tables 4.4-3, 4.4-4 and 4.4-17) in the Rapid Transit sections under EXISTING CONDITIONS and PROBABLE PROJECT IMPACTS have been revised to reflect the changed estimates of line capacity.

Comment -- "There is also a significant discrepancy in the number of PM peak hour transit trips generated by the project - Table 4.4-9 gives 898 trips whereas Table 4.4-14 in the transit analyses section gives only 626. This discrepancy needs to be corrected or explained adequately."

Response -- There is no discrepancy between the two tables because Table 4.4-9 (now Table 4.4-10) refers to total project-generated public transportation trips, while Table 4.4-14 (now Table 4.4-16) refers to project-generated rapid transit trips. As noted in the text, 70 percent of all public transportation trips into downtown are estimated to be rapid transit trips. The remainder are bus and commuter rail trips. This estimate is based on the 1982 Cordon Count for Downtown Boston.

Comment -- "With regard to parking, the Draft EIA indicated a shortfall of 62 long-term spaces and 95 short-term spaces. The Final EIA should describe where parking demand surplus would go or what the impact would be on adjacent areas, particularly Chinatown."

Response -- The parking analysis in the FEIA indicates that a total of 400 parking spaces is planned. The projection of long-term parking demand is for 362 spaces. Therefore, no short-fall in long-term spaces is projected.

A shortfall of 95 spaces for short-term parking is still anticipated. One response to this short-term parking shortfall might be a shift to public transportation or increased ride- sharing (higher vehicle occupancy rate). The other response to the shortfall of on-site parking would be for drivers to seek parking at other off-site locations. However, little or no excess parking capacity can be expected at other locations near the site. As a

result, drivers may have to park at more distant locations. The results in either case would be less automobile traffic in the immediate area of the site, including Chinatown, than was projected in the DEIA.

Comment -- "The Final EIA and Access Plan should also address the need for short-term parking. In addition, the location of potential off-street parking during construction should be described."

Response -- As shown in the FEIA, a need for 95 short-term spaces will exist based on projected trip generation. Because of the downtown parking freeze, no new commercial parking spaces may be added downtown. Therefore, the developer is unable to provide additional short-term parking. Lack of on-site availability of nearby spaces will require use of existing off-site spaces. However, the limited availability of nearby off-site spaces will result in a shift to other modes such as transit or walking, or to the use of more remote parking locations where spaces may still be available. At a downtown location such as 125 Summer Street, a substantial number of non-work walk trips from other nearby downtown developments would be expected.

As indicated in the Final Access Plan, no construction worker parking will be permitted on-site or adjacent to the construction area. Constructions workers will be required to access the site by public transportation, ridesharing, or by parking at an off-site location. The most likely off-site location for construction worker parking will be at the lots located along Northern Avenue across the Fort Point Channel. The contractor for the project indicates that the Northern Avenue lots are a common location for construction worker parking because of their comparatively low cost.

Comment -- "Maps indicating LOS at the studied intersections and pedestrian volumes would be useful for reference and should be included in the Final EIA."

Response -- Figure 4.4-13 has been included in the capacity analysis section to show existing and projected levels of service at study intersections in the AM and PM peak hours. Figures 4.4-5, 4.4-6, 4.4-14 and 4.4-15 have been added to show existing an future AM and PM peak hour pedestrian volumes.

Air Quality Analysis

Comment -- "The air quality analysis of the Draft EIR was reviewed by both the Department of Environmental Quality Engineering and by a consultant (Tech Environmental, Inc.) under contract to the BRA. Their reports are attached. As discussed at a recent meeting of your consultants, the BRA and DEQE, a revision of the air quality analysis will be required for the Final EIA. Prior to the re-analysis, the methodology, assumptions, receptor locations, and other input data should be reviewed with DEQE and the BRA should be notified when this meeting is scheduled."

Response

The air quality analysis for the Final EIA has been completely remodelled and rewritten. Methodology, assumptions, receptor locations, and other input data have been reviewed by both the DEQE and the BRA prior to initiating the air quality analysis. Tech Environmental, Inc. comments were incorporated into the final criteria.

Comment -- "In addition, the air quality analyses includes minimal discussion of the large violations of the carbon monoxide standards that are predicted, fails to demonstrate consistency with the Massachusetts State Implementation Plan, and fails to show that the project will not interfere with the attainment and maintenance of the standards. Even though existing and 1989 No-Build conditions are projected to exceed standards, the project itself will increase the violations. No measures to fully mitigate the increase are suggested. This failure must be corrected in the Final EIA, in consultation with DEQE."

Response

Section 4.5.6, Mitigating Measures, fully discusses possible mitigation of NAAQS exceedances and feasibility of these measures in the near future. These measures include traffic demand reduction measures to which the project proponents are directly committed, suggest signal timing changes, and the effects a number of planned traffic improvements will have in the area.

Comment -- "Although a number of measures to mitigate dust emissions during construction are identified in the report, a strong commitment to the implementation of these measures and monitoring of compliance will be required."

Response -- The construction contract will provide for a number of strictly enforced measures to be utilized by contractors to reduce potential fugitive dust emissions and minimize impacts. These measures are detailed in Section 4.5.8.

Historic Quality Impacts

Comment -- "The Final EIA should include a discussion of reviews of the project with the Massachusetts Historical Commission, Boston Landmarks Commission, and Preservation Alliance."

Response -- During project planning stages throughout 1986, project proponents, consultants, and architects met with respresentatives of the above organizations on numerous occasions. Project plans were presented. These organizations each expressed support for the project, in particular, inclusion of historic buildings into the design and a sensitive and historically compatible design of the new structure.

Comment -- "On page 4.7-2, it is stated that no buildings on the site have been classified by the Boston Landmarks Commission as being in categories I, II, or III. However, the BLC's Central Business District Preservation Survey clearly lists 115-117, 131-135, and 137-139 Summer Street as Category III (Significant) buildings. This should be corrected in the Final EIA."

Response -- The text has been revised to accurately list buildings classified as Category III. All buildings within the project area have been surveyed by the Boston Landmarks Commission as part of its Central Business District Preservation Study. None has been classified as either Category I (Highest Significance) or Category II (Major Significance). Buildings at 115-117, 131-135, and 137-139 Summer Street are noted as Category III (Significant) buildings.

Comment -- "On page 4.7-6 (#7), the Great Fire occurred in 1872, not 1972."

Response -- The text has been corrected to state the Great Fire occurred in 1872.

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS (MEPA UNIT)

Summary of Comments -- The MEPA Unit's comments address the EIR process and design issues. The focuses were directed at the review process and did not include any specific matter relating to the DEIA. The comment on design was a general call for EIRs to elaborate on design concepts.

Response -- The Project Description has been enhanced somewhat to reflect design and proposed street level uses of the project. The FEIA is only one part of the BRA's review efforts of projects of this type and magnitude. Design/development submissions by the proponent go into far greater design detail than is possible in an environmental impact analysis.

COMMISSION, TRAFFIC, AND PARKING

Summary of Comments -- Commissioner Diminio's comments noted that the DEIA "adequately describes the impact of the project on the immediately surrounding transportation facilities."

Response -- The proponents and their transportation consultants had met with Commissioner Diminio's staff to resolve construction impact mitigation.

STEPHEN H. KAISER - JUNE 16, 1986

Summary of Comments -- There were extensive comments that can be grouped into the following subject matters. Each is followed by a response.

Alternatives -- "Simple rehabilitiation and low-rise infill of the existing buildings."

Response -- The project seeks to retain four existing buildings to form the base of the new building. A simple low-rise infill is not a feasible alternative. Realistic alternatives (besides No-Build) included a taller building on the site. The proposed building is the result of a review process that reduced the height and density of earlier alternatives.

Wind -- The comments on wind centered on comparative studies with other wind analyses and the extent of exceedences of the "hot spots" where predicted wind exceeded BRA criteria.

Response -- This wind study was not done in isolation of others, as claimed in the comment. However, it is true that different studies have tended to show varying results. Such variations are due to differing model techniques, wind tunnel characteristics, and methodologies. The methods employed for this study are conservative and allow for predictable wind impacts between the Build and No-Build alternatives. Comparison of results with other studies do not reveal any new insight. The discussion on exceedences are responded to in our responses to the BRA in subsection 4.1.5.3 and 4.1.5.4.

Transit Analysis -- This comment was concerned with the quality of the transit analysis.

Response -- The BRA letter raised the same concern. Our response is provided in subsection 2.0, page 2.2-14.

STEPHEN H. KAISER - JULY 7, 1987

Summary of Comments -- The second letter from Mr. Kaiser was concerned with the Access Plan and Air Quality Study which appeared in the supplementary report of the DEIA.

Response -- Responses to comments on the Access Plan are provided in detail in the responses to the BRA letter and in amendments to the Access Plan text. Furthermore, in response to the BRA requirement, the Air Quality study was completely revised.

TECH ENVIRONMENTAL, INC.

Summary -- Tech Environmental, Inc. was retained by the BRA to review the Air Quality study in the DEIA. The letter and subsequent follow-up meetings with the BRA staff resulted in the proponent's agreement to completely revise the Air Quality study.

Response -- Inasmuch as the Air Qualiy study is completely revised, the reader is referred to the Air Quality Summary, or the full Air Quality study, Section 4.5.

BOSTON WATER AND SEWER COMMISSION (BWSC)

Comment -- The description of flow transport in the East Side and Boston Main Interceptors is either incorrect or needs to be updated.

Response -- The entire utility section of the text has been updated. The description of the East Side and Boston Main Interceptors, Section 4.8.3, now correctly details flow transport.

Comment -- Adequacy of Boston Water and Sewer Commission's water lines to supply the projected demands for this project is not addressed.

Response -- A hydrant test conducted in October 1986 indicated an available flow of 3,270 gpm at a satisfactory residual pressure of 50 psi. The results of this test indicate that the low pressure service system in the site vicinity has capacity to satisfy the project demand (peak flow of 170 gpm).

Comment -- The stated average daily water usage (80,000 gpd) estimated for this development appears excessive. Boston Water and Sewer Commission requests figures on the air conditioning water requirements.

Response -- Domestic water demand for this project is expected to total 44,700 gpd. In addition, air conditioning makeup water is expected to average 40,000 gpd. The peak domestic use is estimated at 70 gpm, based on a peaking factor of 3.0 for restaurants, at 2.4 for offices. A peak air conditioning makeup water rate of 100 gpm is anticipated, resulting in a total peak demand of approximately 170 gpm.

3. PROJECT DESCRIPTION

3. PROJECT DESCRIPTION

3.1 Location

The project is located at 125 Summer Street in Boston's financial district. The site is within a block bounded by Summer Street, South Street, JFK Expressway (Surface Artery), and Lincoln Street. Other properties in the immediate vicinity of the subject site include South Station, One Financial Center, 99 Summer Street (under construction), the Fiduciary Trust Building, and the Federal Reserve Bank. Figure 3.1 depicts the location of the site within the downtown area.

3.2 Existing Conditions

The subject site comprises about 31,034 square feet (2/3 acre) and is presently occupied by nine (9) vacant and boarded-up mercantile buildings (See Figure 3.2). The buildings were at one time used for commercial purposes; there were no residential uses on the site. The buildings range in height from two to six stories.

In addition to the existing structures, there exists on the same block, a 70 foot ventilation stack facing the Surface Artery. The ventilation stack serves the underground expressway and is owned by the Commonwealth of Massachusetts. Although it is on the same block as the proposed project, the ventilation stack is not part of the redevelopment project.

The general vicinity is part of the City's financial center which has been undergoing redevelopment with several significant high rise buildings that have been recently constructed or are under construction. These are interspersed with older buildings some of which have been undergoing restoration. Existing views are shown on Figure 3.3 through 3.12. Figure 3.3 is a key map showing the pedestrian level vantage points for each photograph. Figure 3.4 shows the view from Summer Street towards the site. In the foreground are the existing low rise

FIGURE 3.1 PROJECT LOCATION - 125 SUMMER STREET, BOSTON

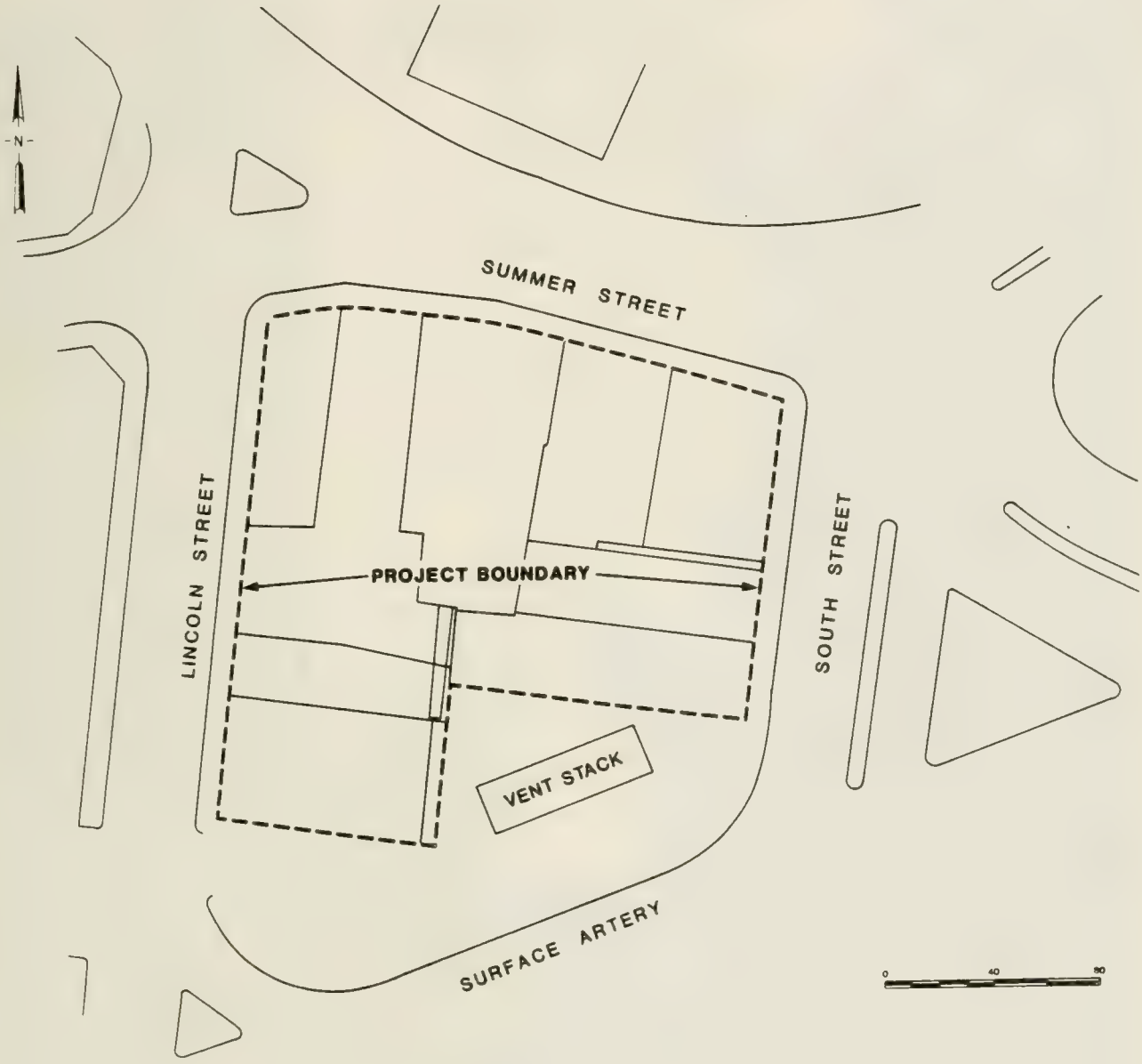
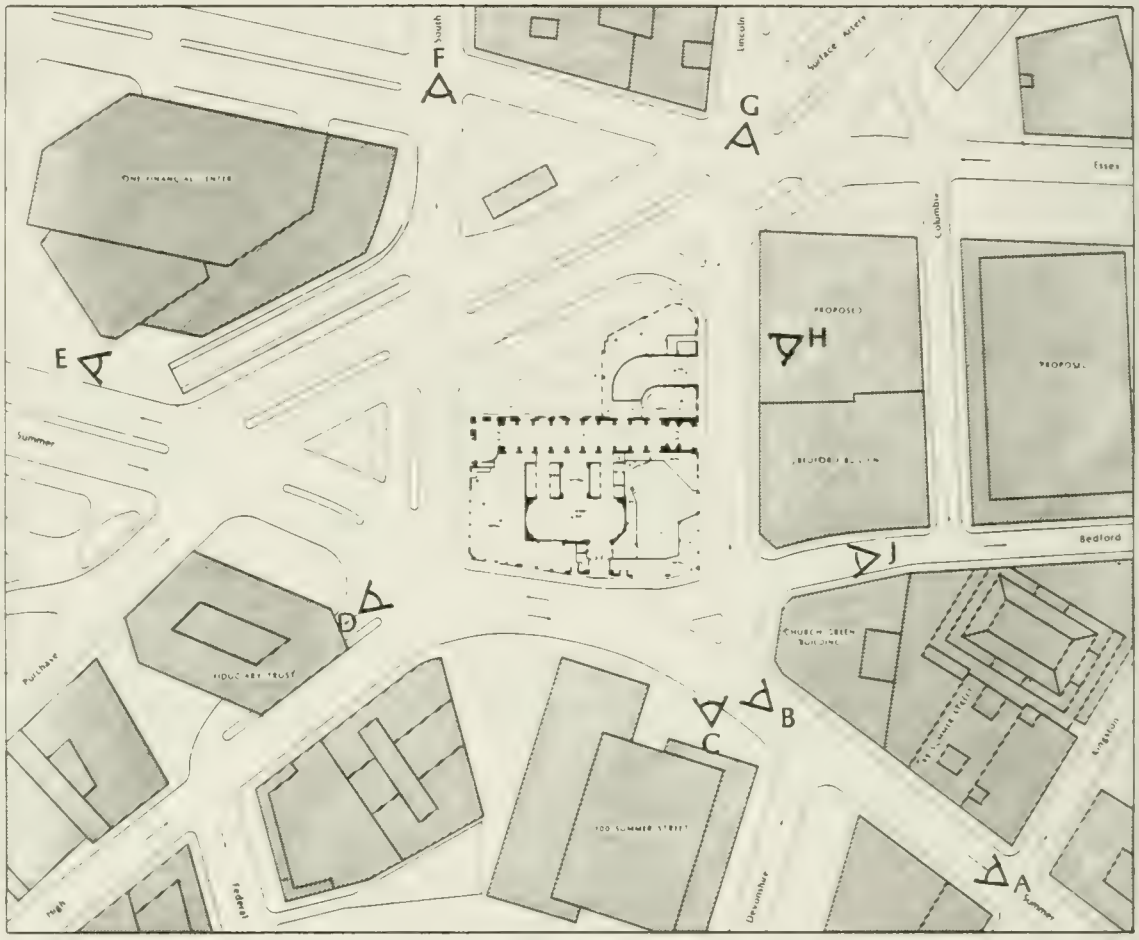


FIGURE 3.2 125 SUMMER STREET - EXISTING CONDITIONS



KEY FOR EXISTING SITE VIEWS

GRAPHIC SCALE: ⊢100'⊣

FIGURE 3.3 KEY FOR EXISTING SITE VIEWS

FIGURE 3.. EXISTING CONDITIONS - VIEW 1

EXISTING CONDITIONS - VIEW B

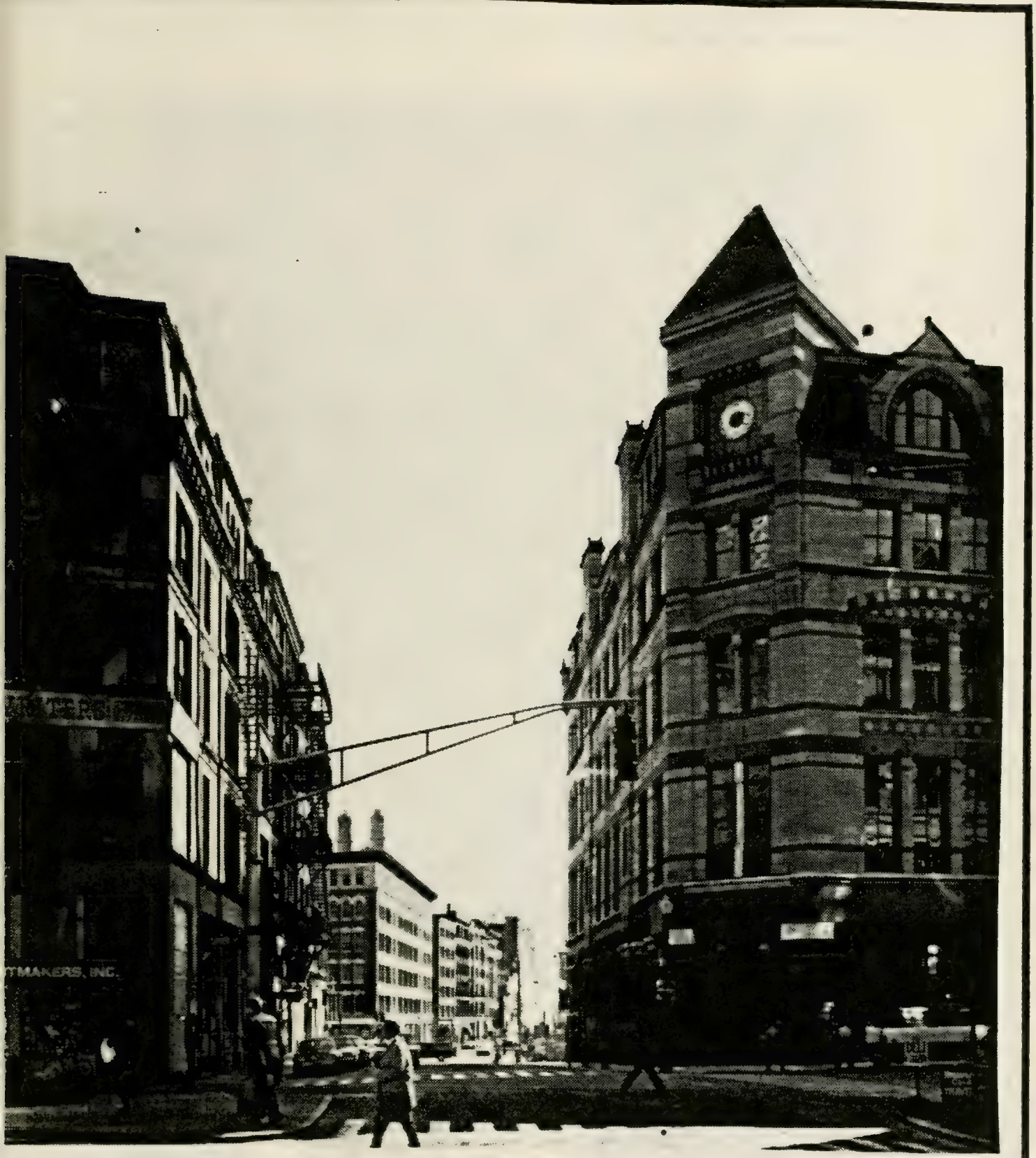


FIGURE 3.6 EXISTING CONDITIONS - VIEW C

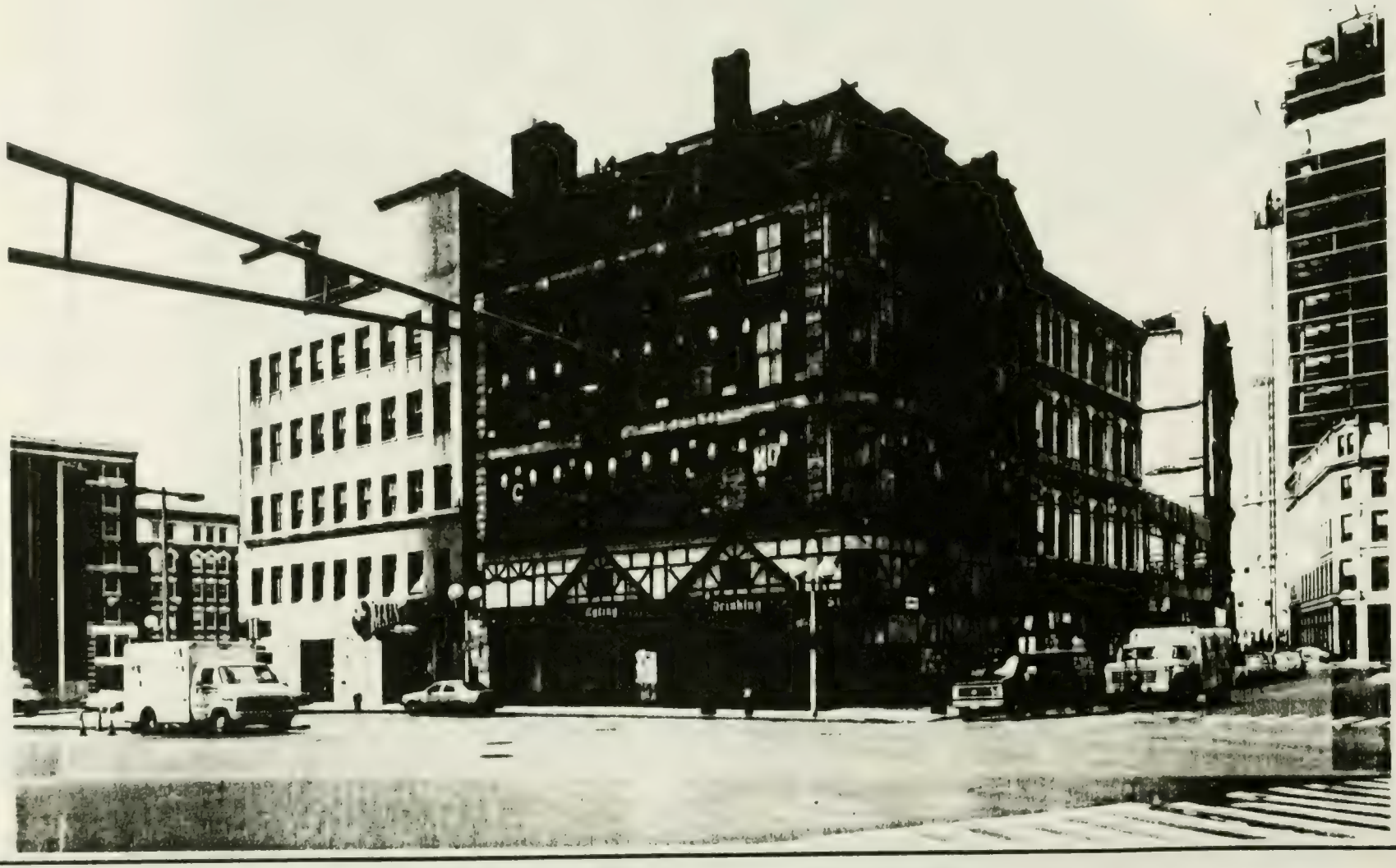


FIGURE 3.7 EXISTING CONDITIONS - VIEW D

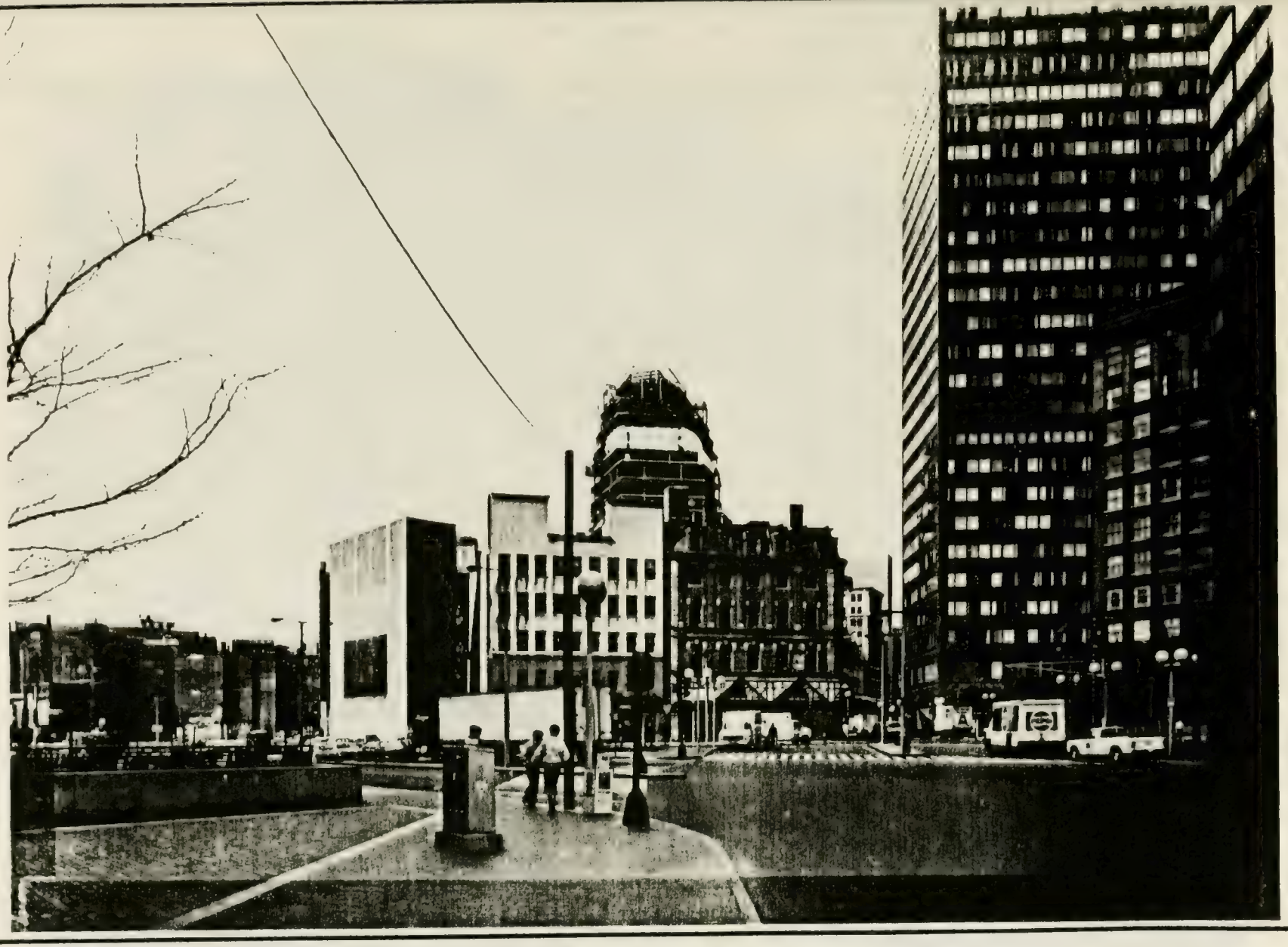


FIGURE 3.8 EXISTING CONDITIONS - VIEW E

1196/0834s

FIGURE 3.9 EXISTING CONDITIONS - VIEW F

FIGURE 3.10 EXISTING CONDITIONS - VIEW G

1196/0834s

FIGURE 3.11 EXISTING CONDITIONS - VIEW H

FIGURE 3.12 EXISTING CONDITIONS - VIEW 3

buildings which will form the base of the proposed new building. In the background is the One Financial Square building and to the right is the 99 Summer Street project, presently under construction. Figure 3.5 also shows a view from Summer Street but from a point closer to the project site. It shows the existing buildings, several of which will form the base of the new building. Figure 3.6 looks to the south along Lincoln Street from the intersection of Summer/Bedford and Lincoln Street. The Bedford Building is on the right and the existing building facades of the project site are on the left. Figure 3.7 shows the corner of South Street and Summer Street of the project-site, again showing structures that will be integrated into the base of the new buiding. Figure 3.8 shows the South Street elevation of the existing site, with the expressway ventilation stack on the left and the 99 Summer Street building under construction in the background. Figure 3.9 shows a view looking northward along South Street with the project site on the left foreground, also showing the ventilation stack. Figure 3.10 is looking north along Lincoln Street. The Surface Artery is in the foreground and the project site in the middle at the corner of Lincoln Street and the Surface Artery. Figure 3.11 shows a clear view of the Lincoln Street elevation of the project site. Figure 3.12 is a view looking east from Bedford Street showing the Bedford Building on the right and the Church Green Building on the left. The project site is on the right beyond the Bedford Building.

3.3 Proposed New Construction

The proposed project consists of an office building with ground level retail and on-site parking. The main office building will measure 295 feet and 5 inches from the street level to the top of the parapet at the building's highest point. The building will contain 22 floors with a 23rd floor that will be used for elevator machinery and ventilation

equipment. The first floor at street level will contain retail shops and a gallery. On-site parking will be located on 5 levels below grade, the lowest elevation being 58 feet below street level.

The building will rest on a 5-story base which will occupy the entire project site. Several existing 19th century buildings will be retained to form a part of the base. They will be connected with arched entrances to the main lobby and gallery. The ground floor space will be occupied by specialty retail shops and restaurants. Access to the ground level retail will be principally through the main entrance to the building's lobby on Summer Street and the two entrances to the gallery on Lincoln and South Streets.

Above the 6th story, the tower will be L-shaped and will taper to 20,000 square feet per story with a further tapering at the 21st through the 22nd stories to about 19,000 square feet per story. The top level will be occupied by mechanical equipment.

The total area in the building will be about 495,000 gross square feet. The uses will be primarily for office space with ground level retail space. The ground level will include building lobbies, a gallery, retail stores, service areas, loading dock, and parking garage entrance. The building will be served by an elevator, mechanical and service core (See Figure 3.13).

Parking will be provided on 5 lower levels with 300 spaces (See Figure 3.14 for the Level 1 plan). Some mechanical spaces will occupy the lowest level as well as the penthouse level.

Access to retail shops in the building lobbies will be through three entrances at Summer Street (main lobby), South Street and Lincoln Street. The latter two will be linked by a pass-through 2 story gallery of retail shops. Pedestrian movements will be permitted on all sidewalks bounding the proposed building and, additionally, through the gallery. Parking and loading will be located entirely within the building. Parking and loading access will be by Lincoln Street only.

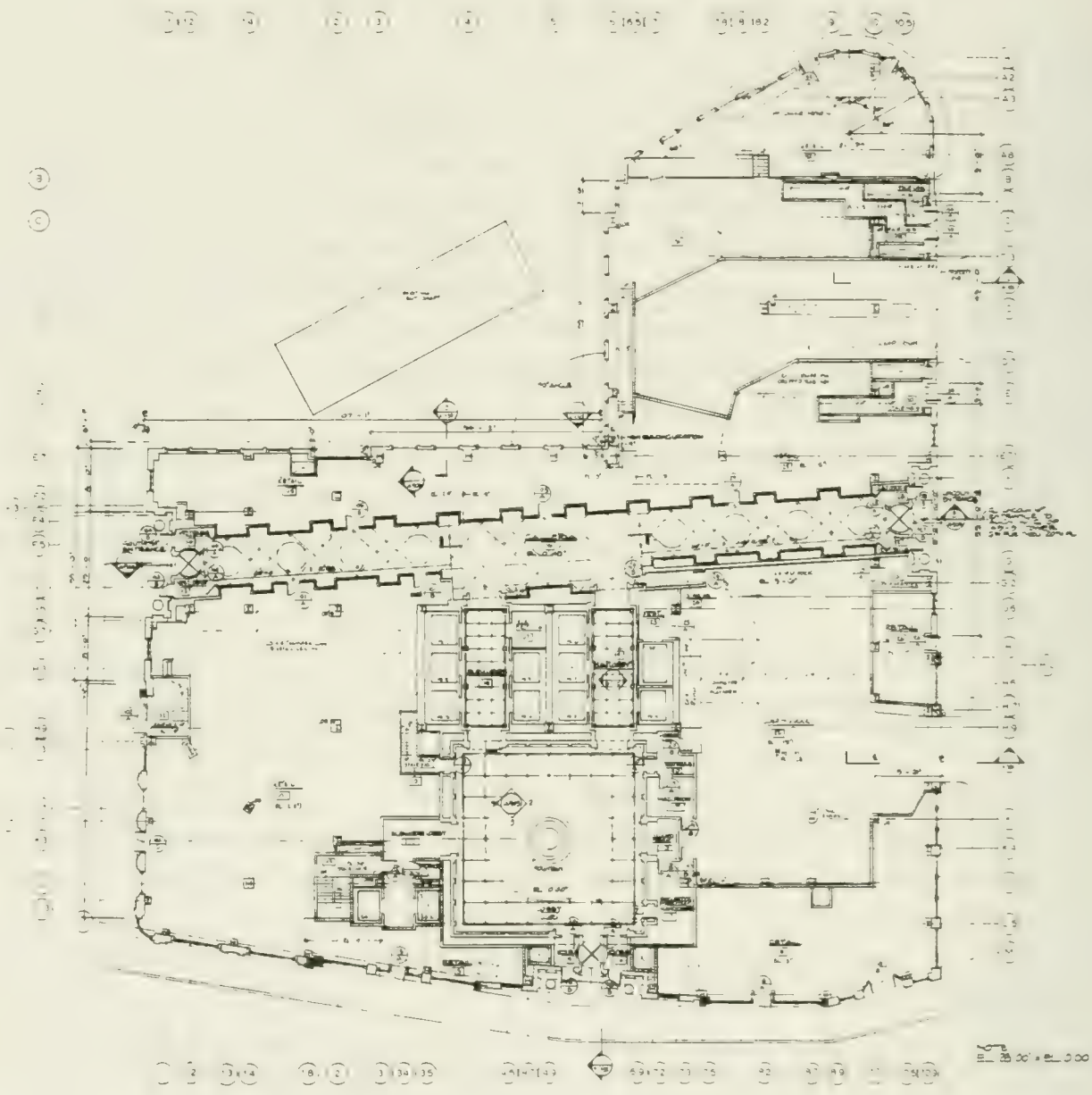


FIGURE 3.13 PROPOSED NEW CONSTRUCTION - GROUND FLOOR PLAN

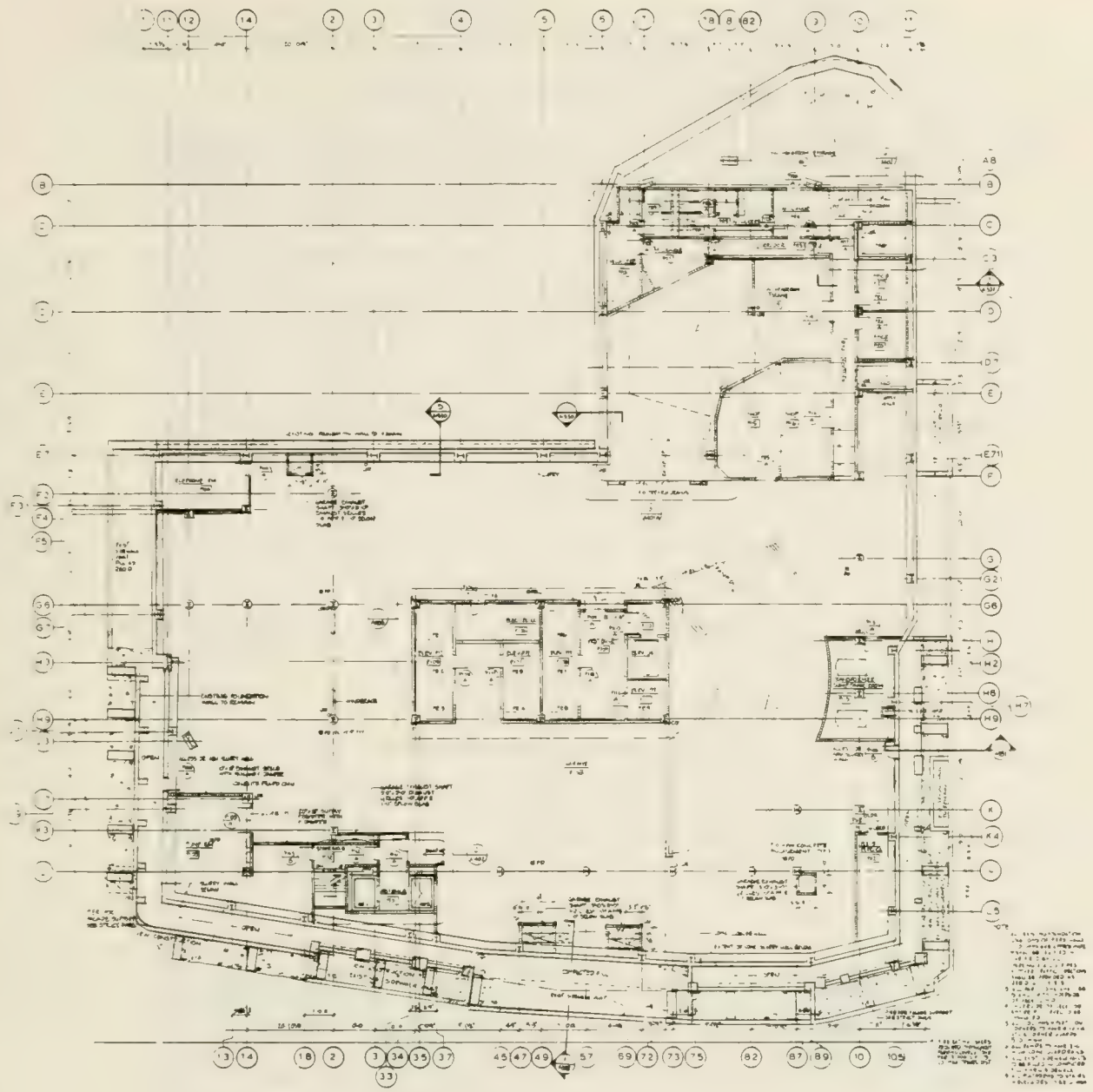


FIGURE 3.14 PROPOSED NEW CONSTRUCTION - PARKING LEVEL ONE

The building is designed to respond to site considerations on each side of the project area. The Summer Street elevation (See Figure 3.15) emphasizes the main entrance to the building lobby. A central 2-story archway which highlights the 5-story low-rise, is flanked by the existing 19th century buildings. These existing structures wrap around the corners at South and Lincoln Streets, helping to retain the existing context of the streetscape. The high-rise portion of the Summer Street elevation has a central vertical panel rising to a vaulted space and flanked by two corner towers, giving symmetry and form to the spaces above the low-rise 19th century buildings.

The Lincoln Street elevation (See Figure 3.16) is similarly highlighted by the arched entrance to the gallery. However, this side will include the entrances to the loading dock and underground parking garage. The low-rise element on Lincoln Street also turns the corners at the Surface Artery and Summer Street, for continuity. The high rise face on Lincoln Street is different from that facing Summer Street with two vertical panels rising to the top towers with its vaulted space.

The Surface Artery elevation is interrupted by the existing vent stack. However, its low-rise element picks up the continuity of the Lincoln Street side, while the high-rise portion accentuates the vertical panels with the corner of the L-shaped building rising to the unifying element of the top towers and connecting vault (Figure 3.17).

While Summer Street is the front entrance, the South Street elevation presents a most dramatic view (See Figures 3.18 and 3.24). The low-rise 19th century structure continues to flank the arched entrance to the gallery. The high-rise accentuates it's L-shape with a rounded corner facing South Street. The top towers are visible but less prominent than the imposing curvature of the main tower whose height is accentuated by vertical panels rising to the top.

As noted earlier, each side has a top-tower connected by vaults which serve as a unifying design element for the main tower. The major exterior building material is proposed to be stone in keeping with 19th century commercial architecture.

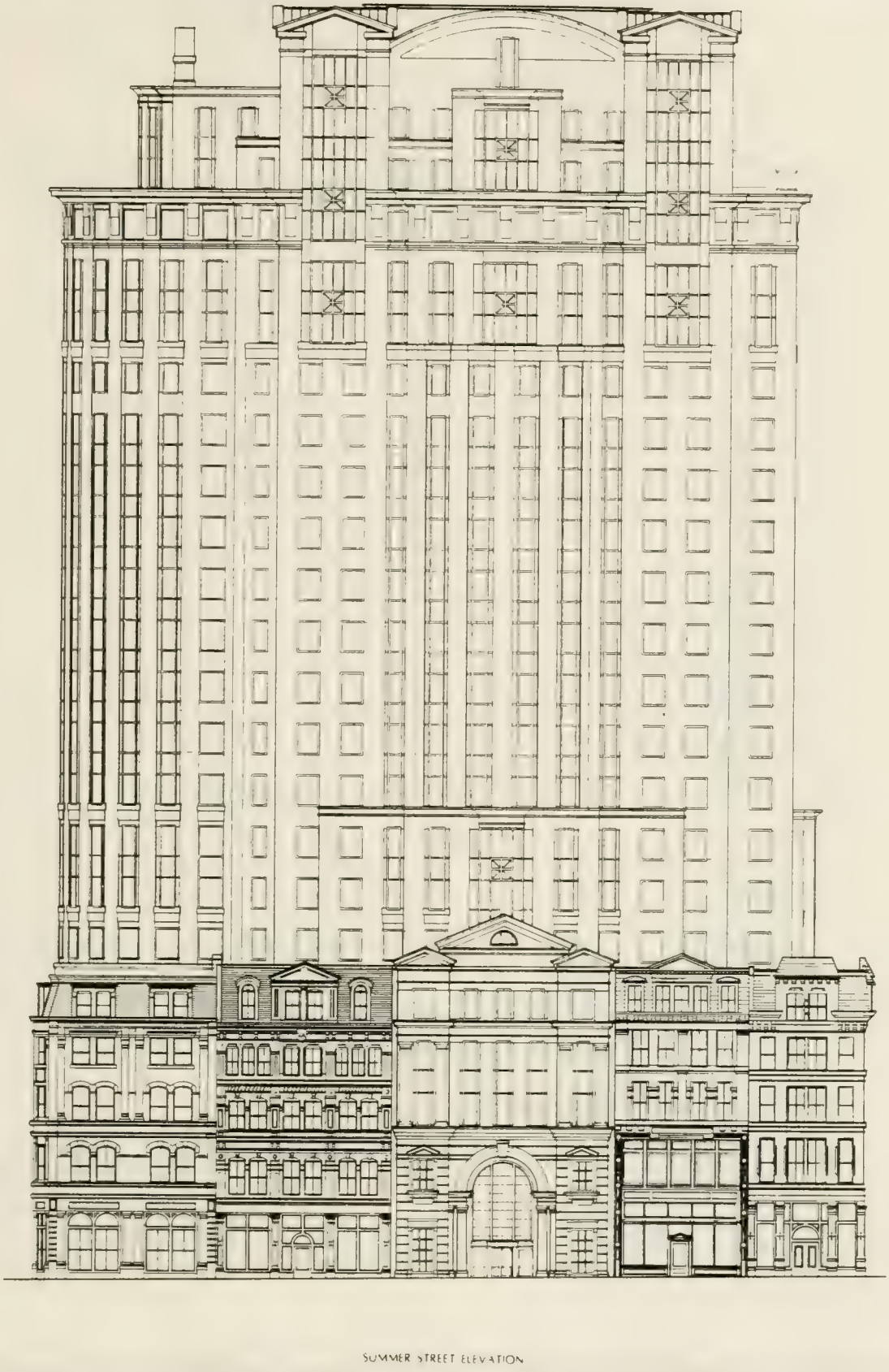


FIGURE 3.15 PROPOSED NEW CONSTRUCTION - SUMMER STREET ELEVATION

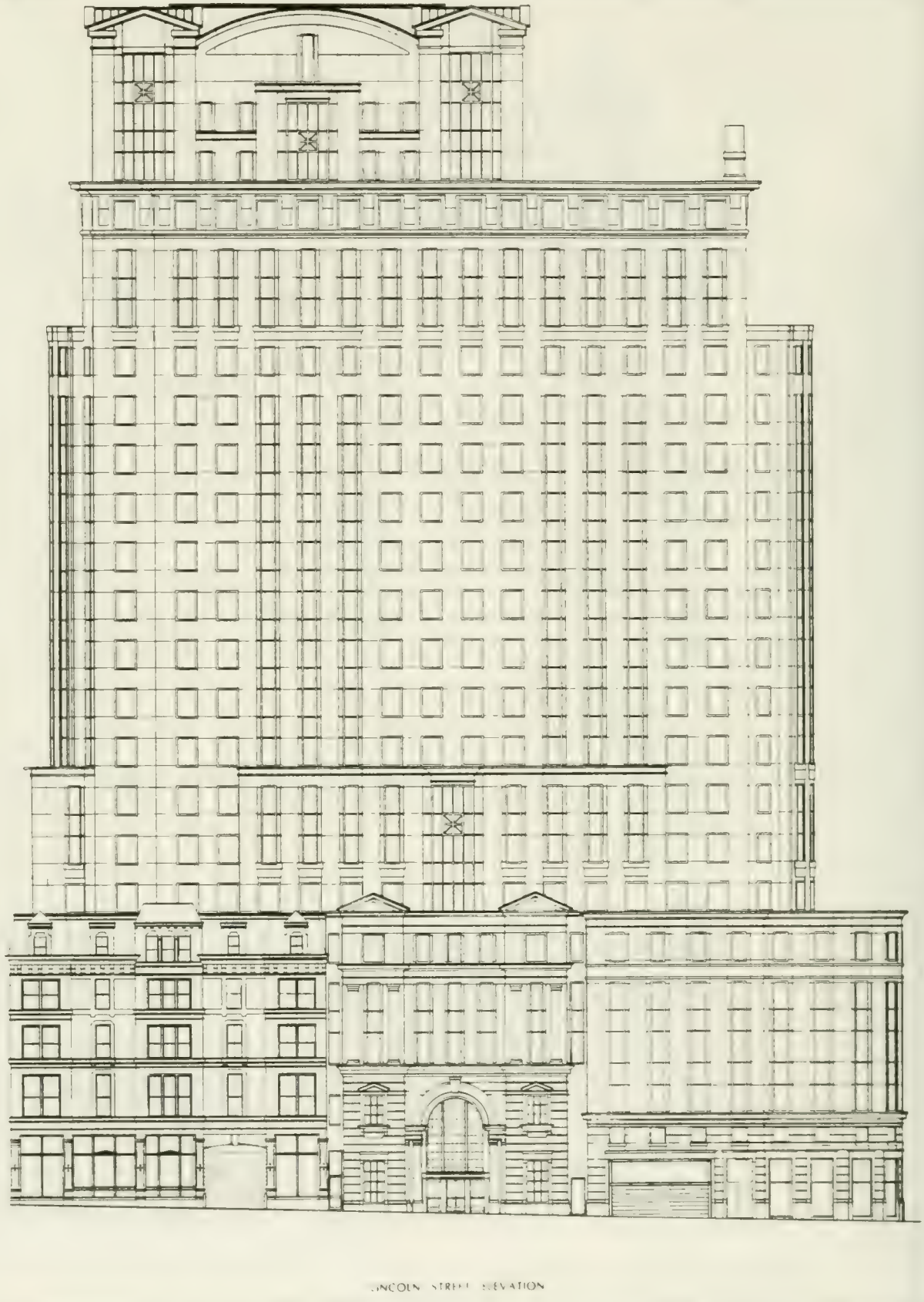
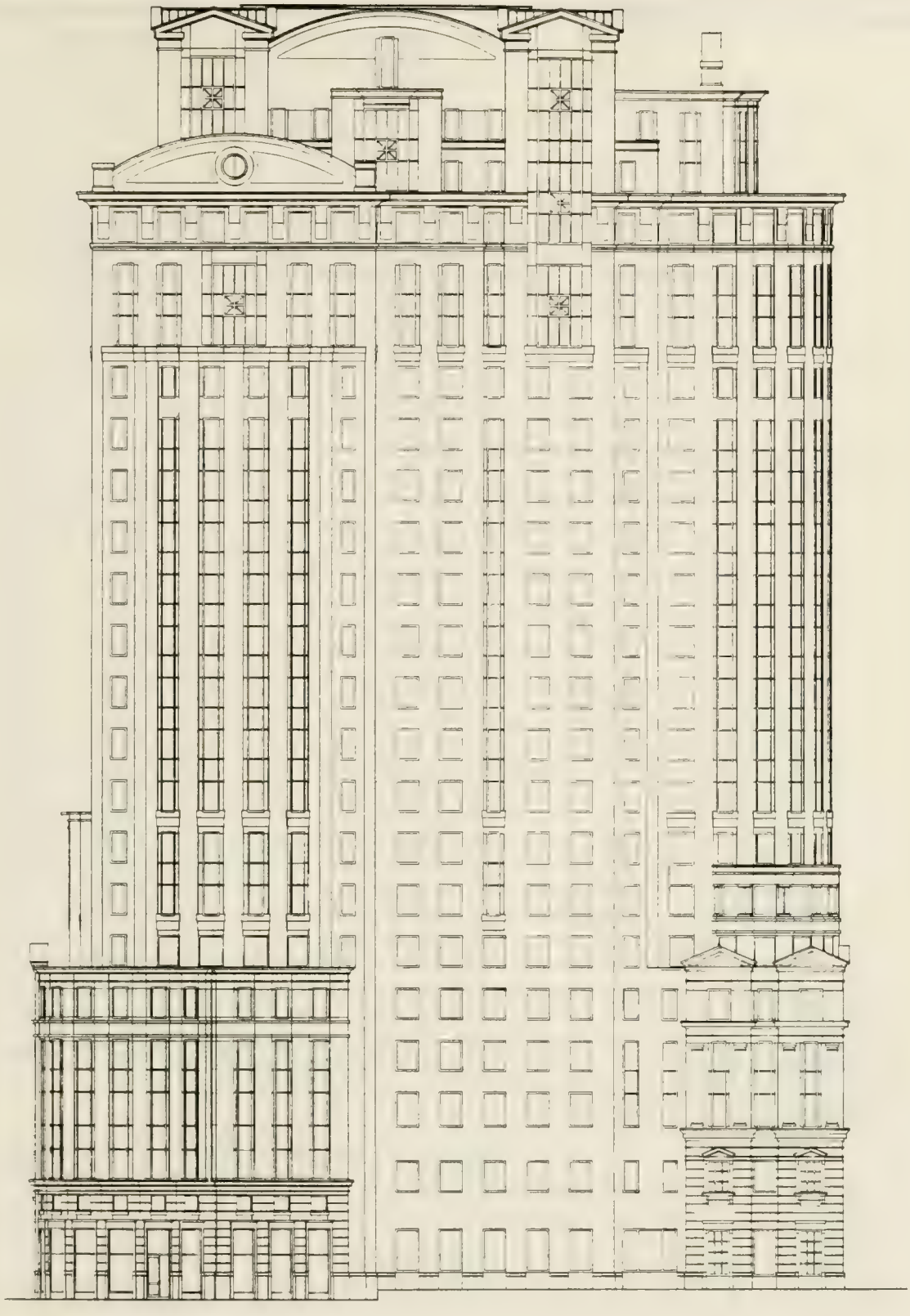
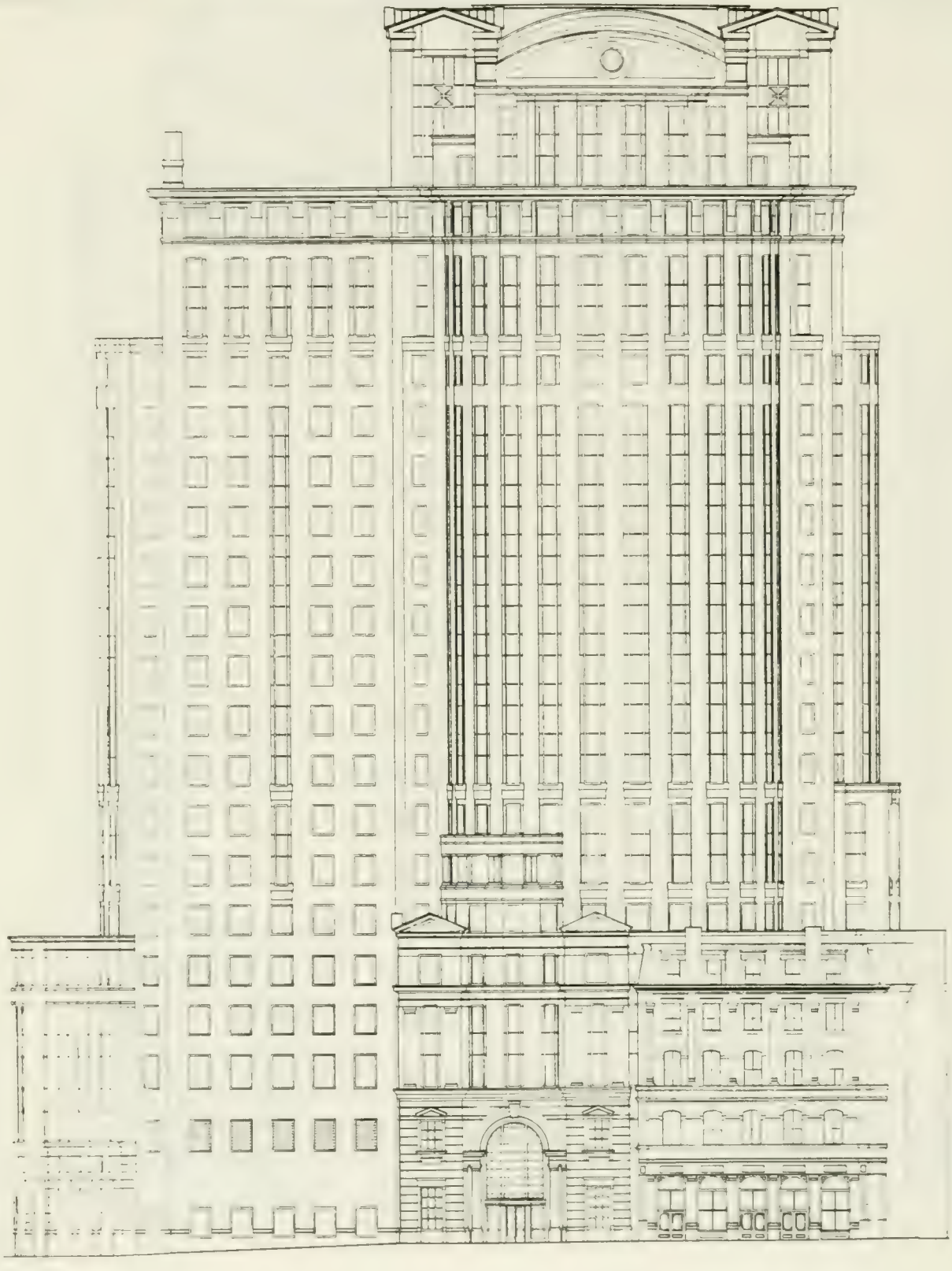


FIGURE 3.16 PROPOSED NEW CONSTRUCTION - LINCOLN STREET ELEVATION



SURFACE ARTERY ELEVATION

FIGURE 3.17 PROPOSED NEW CONSTRUCTION - SURFACE ARTERY ELEVATION



SOUTH STREET ELEVATION

FIGURE 3-18 PROPOSED NEW CONSTRUCTION - SOUTH STREET ELEVATION

In scale and massing, the proposed new building will fit within the context of recent buildings and buildings under construction in the area. At 300 feet, the new building will closely match the height of 99 Summer Street and will be well under the 590 feet of the One Financial Center Building. On Summer Street, the 100 Summer Street building at over 400 feet will loom above the proposed building. The proposed building's base, L-shaped tower and varied facades on four sides combine to minimize its mass and height.

The next set of figures illustrate the major points relating to scale and mass. Figure 3.19 shows a cut-off section looking southwest. The heights of 99 Summer Street at 280 feet and One Financial Center at 590 feet are shown. Figure 3.20 illustrates the new building's relationship to 100 Summer Street. Several photographs of the model depict the scale of the proposed building in the context of the neighboring buildings. Figure 3.21 shows the project looking towards the southeast. The proposed building is in the right foreground with 100 Summer Street just to its left and One Financial Center just above it. The varied facade treatment of the proposed building is also contrasted with the steel and glass exteriors of the adjacent skyscrapers. A different view in Figure 3.22 illustrates the same point. The proposed building is in the foreground and is contrasted with the One Financial Center Building on the right and 100 Summer Street to the immediate left of the proposed building. Further to the left is 99 Summer Street which will be approximately the same height as 125 Summer Street. Figure 3.23 shows the view from Summer Street. Looming behind the new building is the One Financial Center Building. Figure 3.24 shows the photograph from Dewey Square. The L-shape configuration, the integration of the 19th century structures with the new building's vertical panels, window treatment, stone exterior and corner towers with vaulted space provide an interesting and lively treatment. The design displays great respect to the historic setting which will maintain the existing fabric and rhythm of this part of the city.

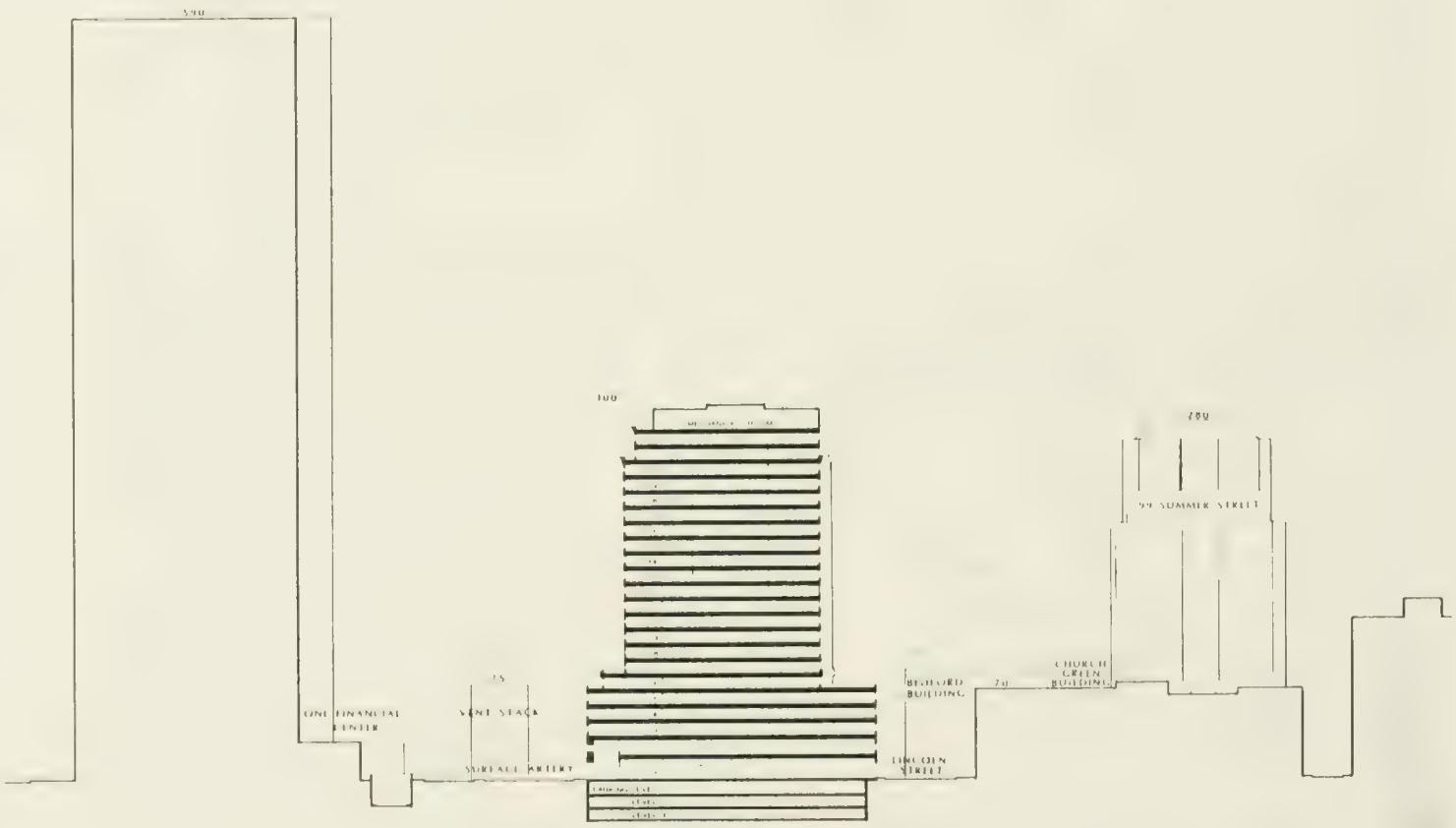


FIGURE 3.19 SITE SECTION LOOKING SOUTHWEST

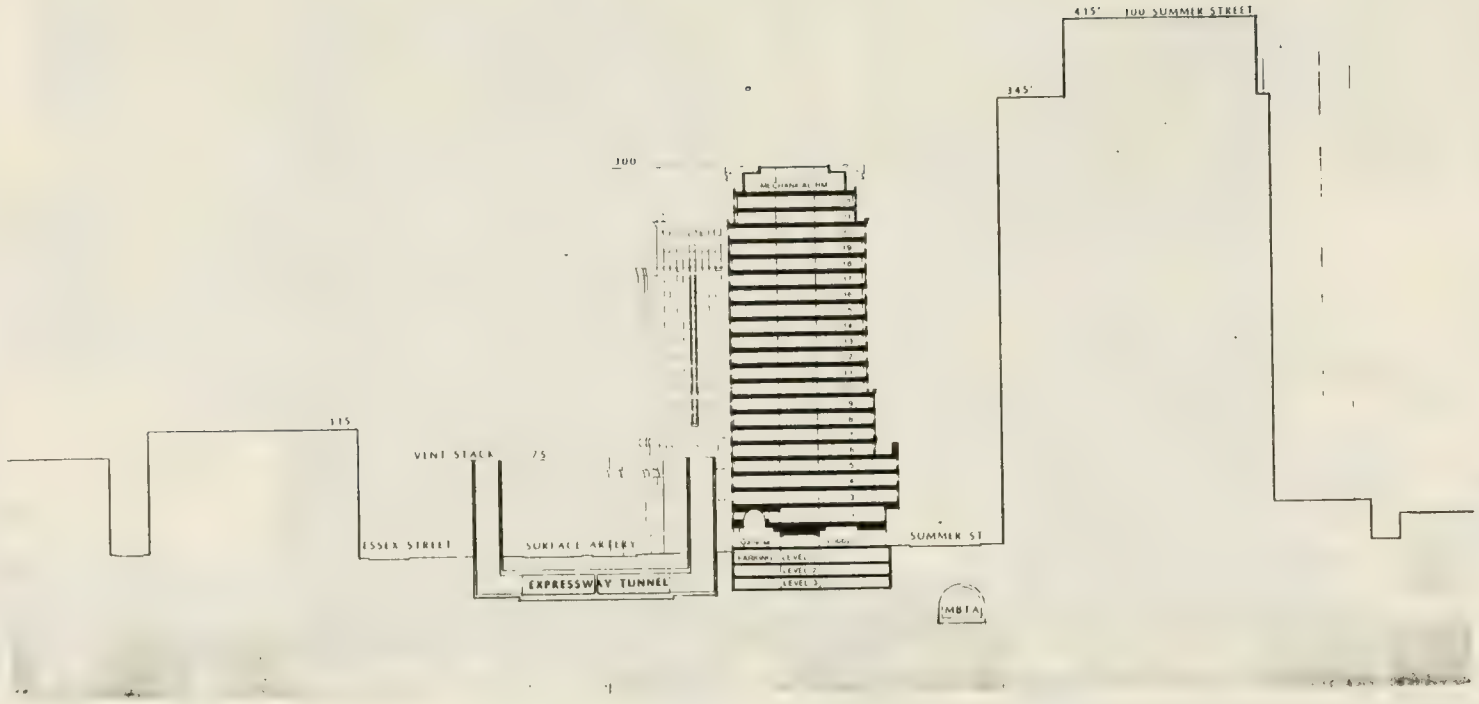


FIGURE 3.20 SITE SECTION LOOKING WEST

1196/0834s

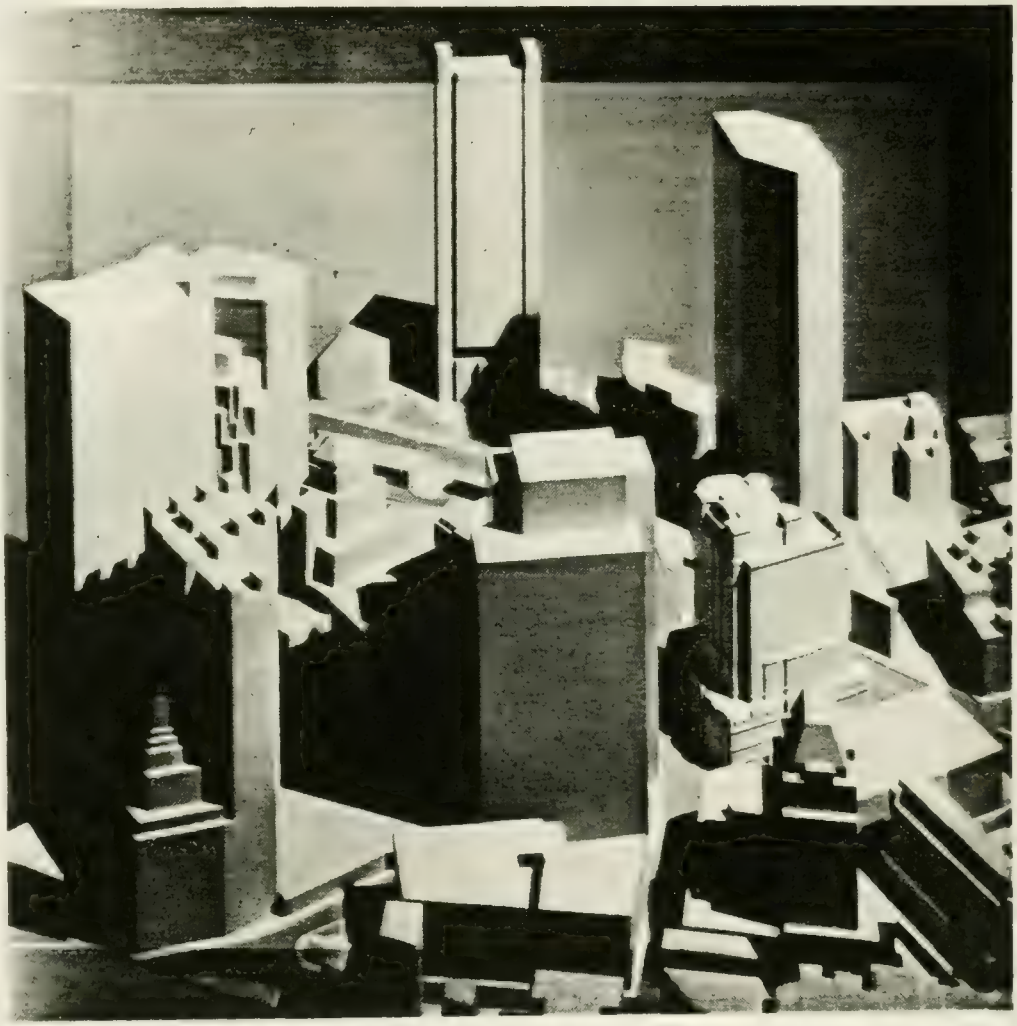


FIGURE 3.21 MODEL PHOTOGRAPH LOOKING SOUTHEAST

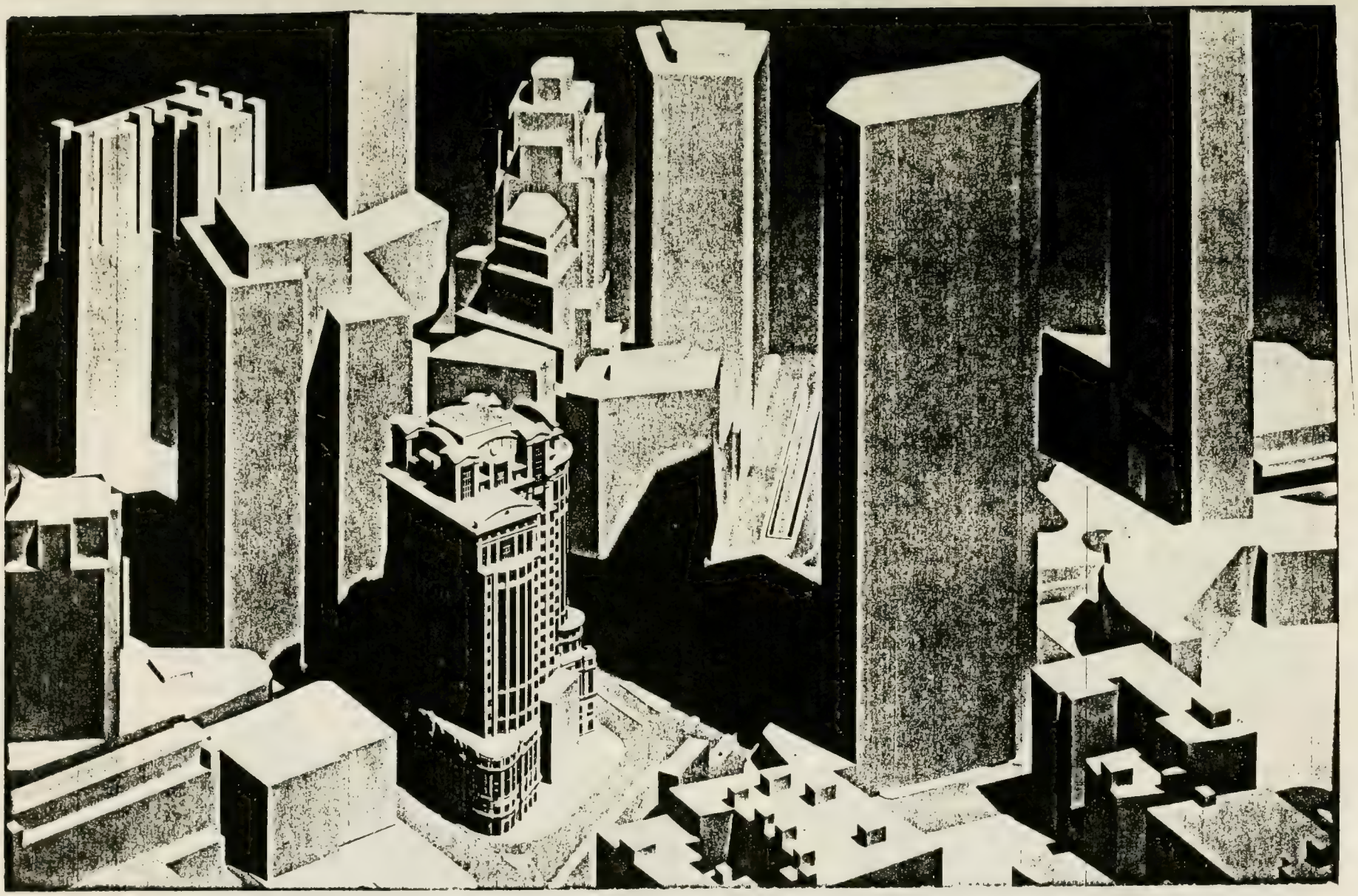


FIGURE 3.22 MODEL PHOTOGRAPH LOOKING NORTHEAST

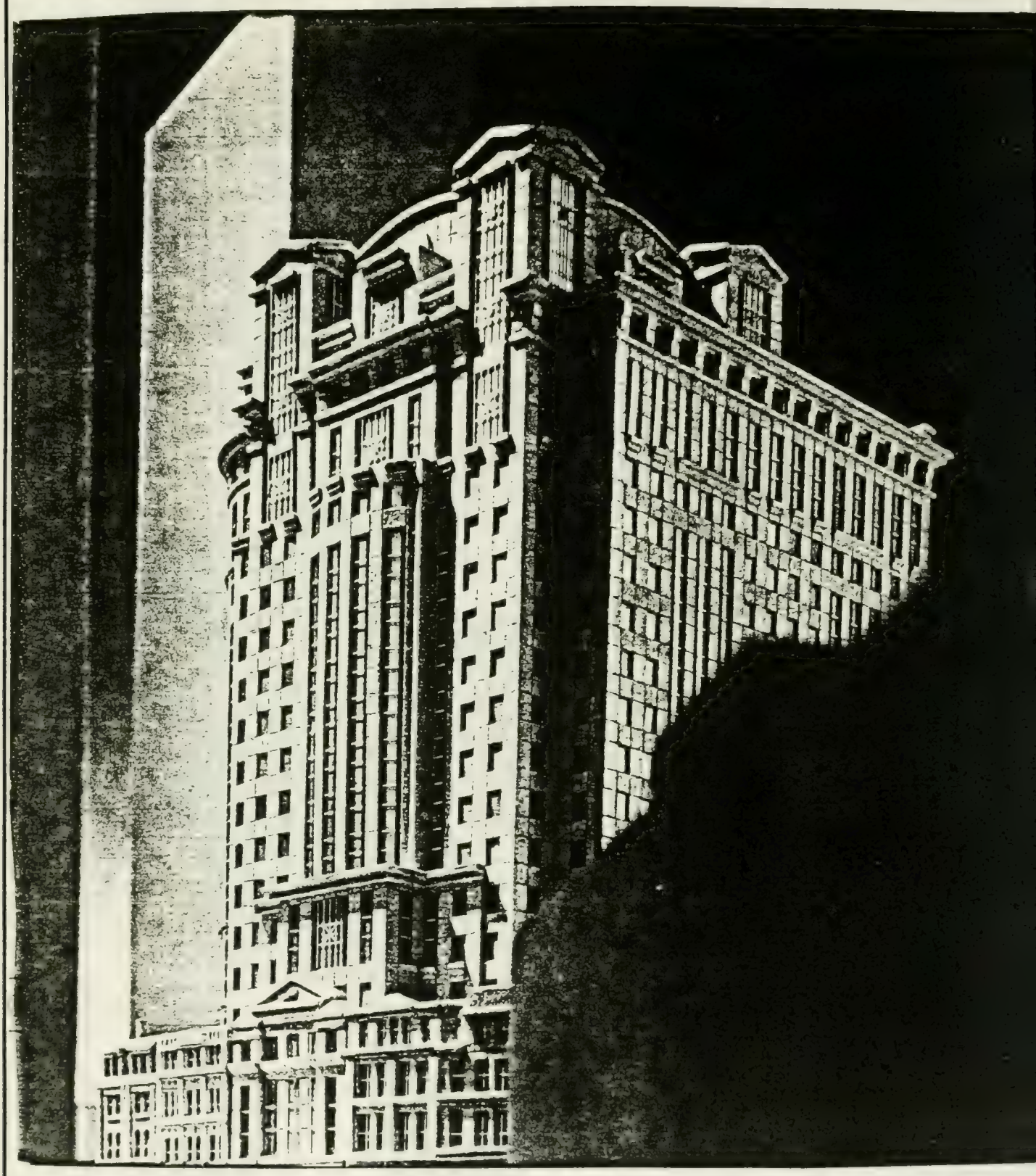


FIGURE 3.23 SUMMER STREET PERSPECTIVE

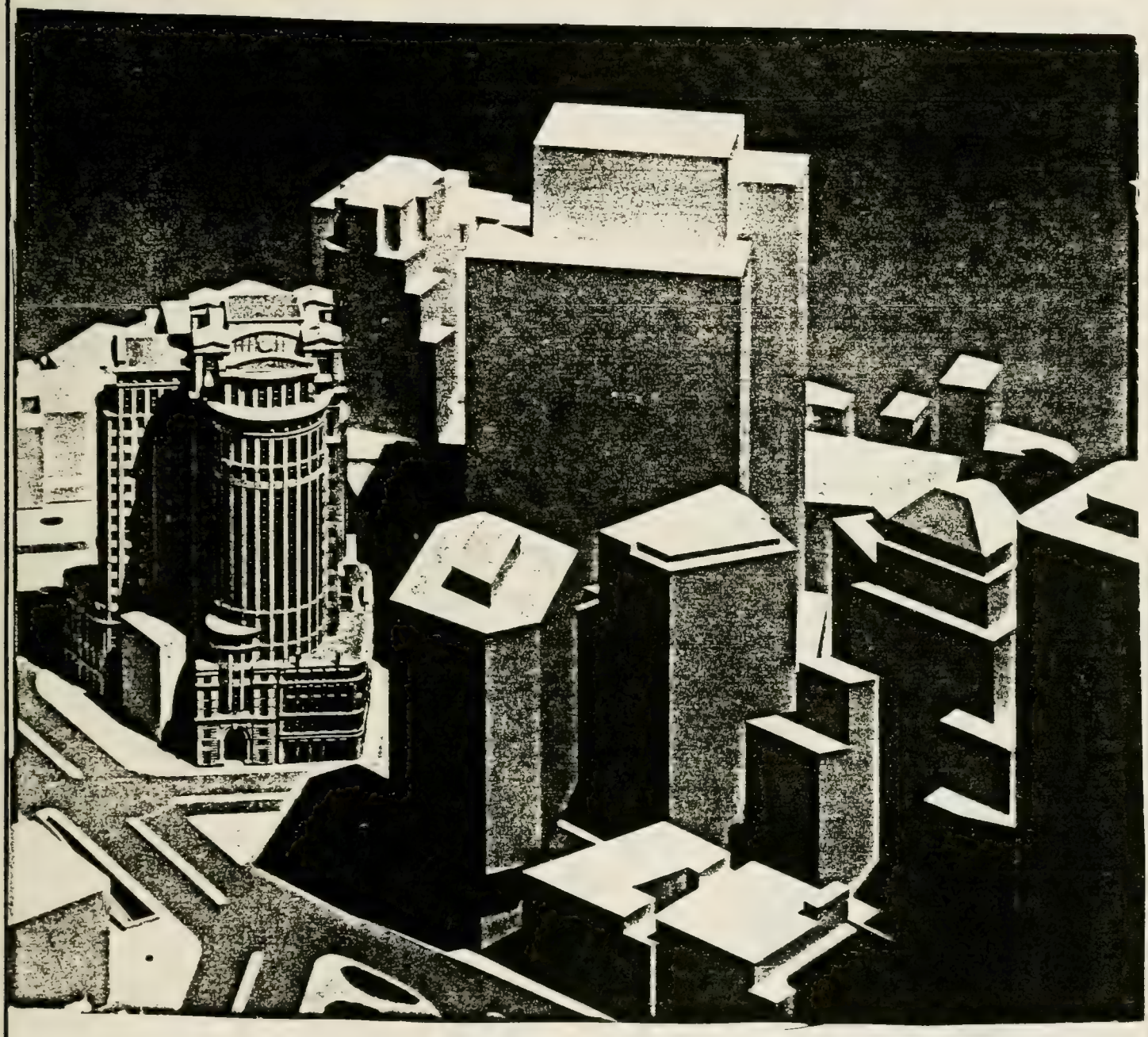


FIGURE 3.24 PROPOSED NEW CONSTRUCTION -
DEWEY SQUARE PERSPECTIVE

FIGURE 3.1 PROJECT LOCATION - 125 SUMMER STREET, BOSTON

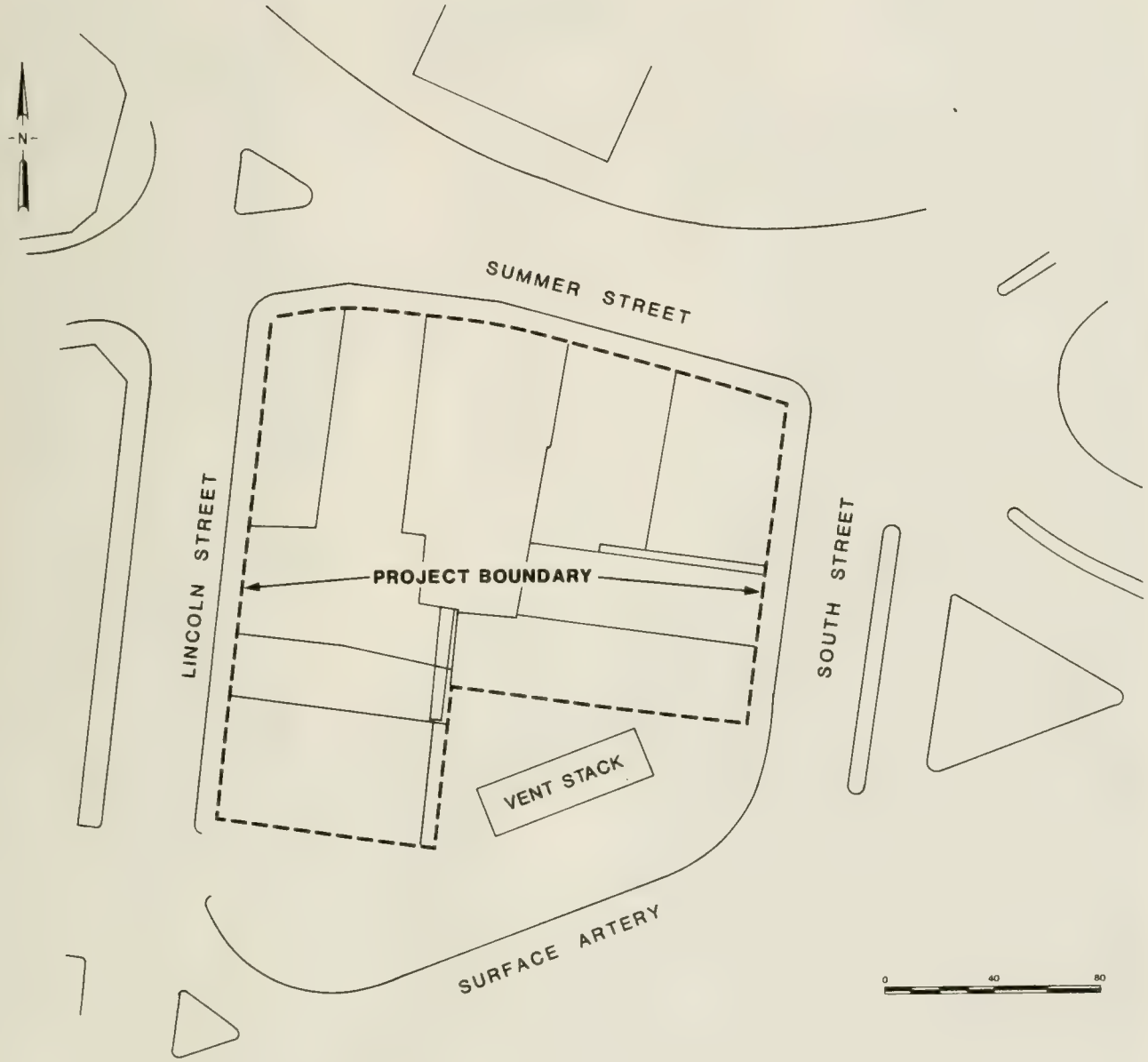
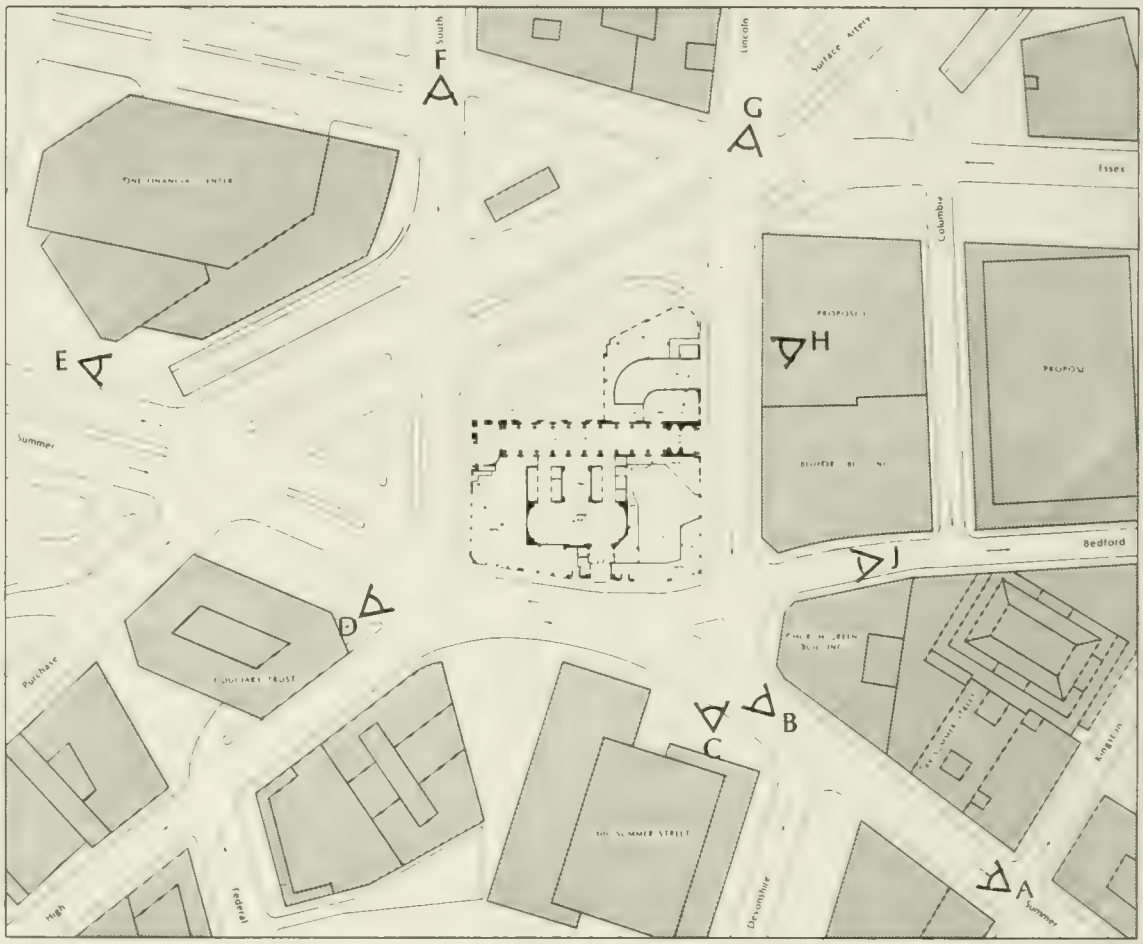


FIGURE 3.2 125 SUMMER STREET - EXISTING CONDITIONS



KEY FOR EXISTING SITE VIEWS

GRAPHIC SCALE: ⊢100'⊣

FIGURE 3.3 KEY FOR EXISTING SITE VIEWS

FIGURE 3.4 EXISTING CONDITIONS - VIEW A

FIGURE 3.7 EXISTING CONDITIONS - VIEW D

FIGURE 3.8 EXISTING CONDITIONS - VIEW E

FIGURE 3.9 EXISTING CONDITIONS - VIEW F

FIGURE 3.10 EXISTING CONDITIONS - VIEW G

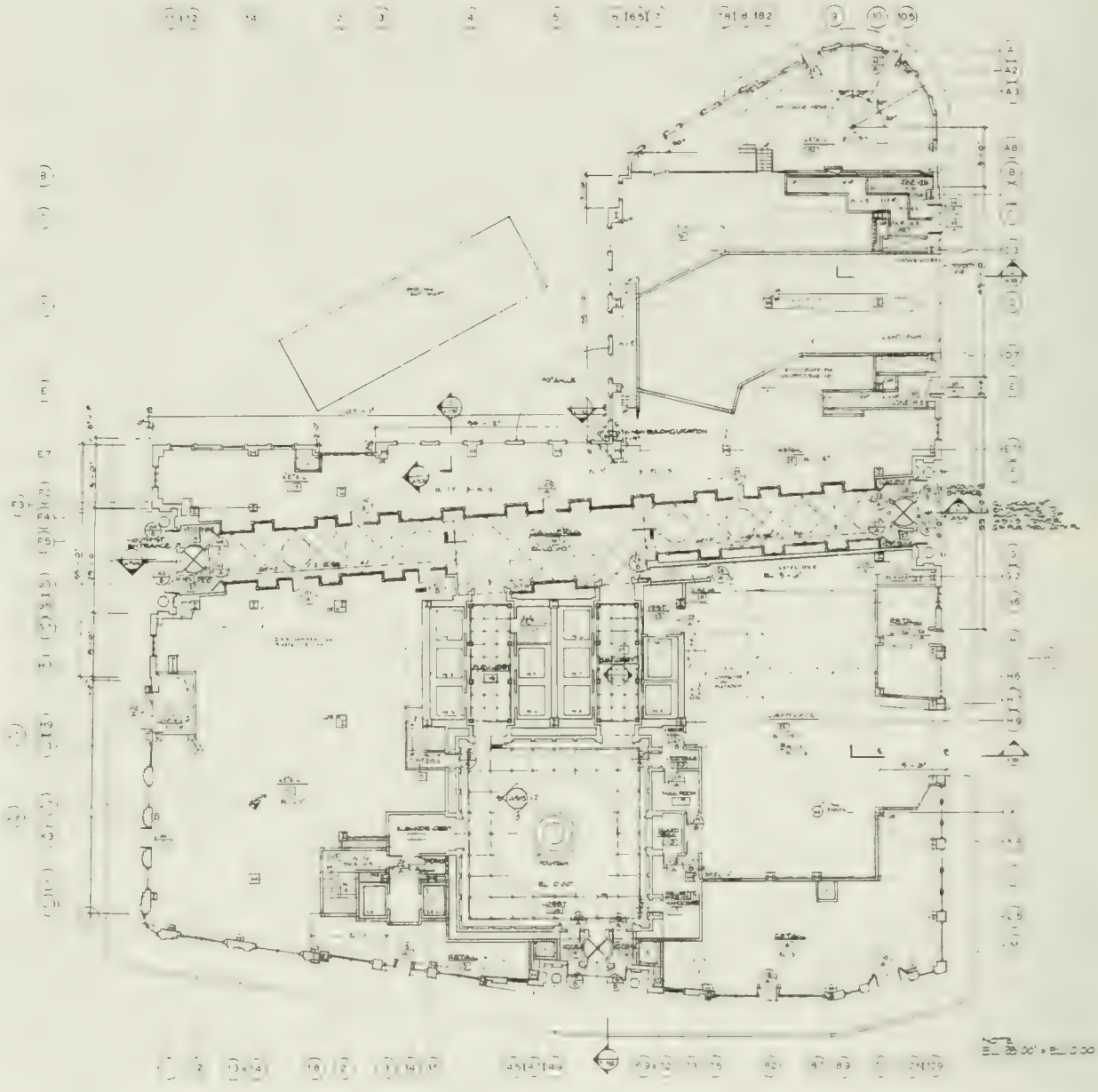


FIGURE 3.13 PROPOSED NEW CONSTRUCTION - GROUND FLOOR PLAN

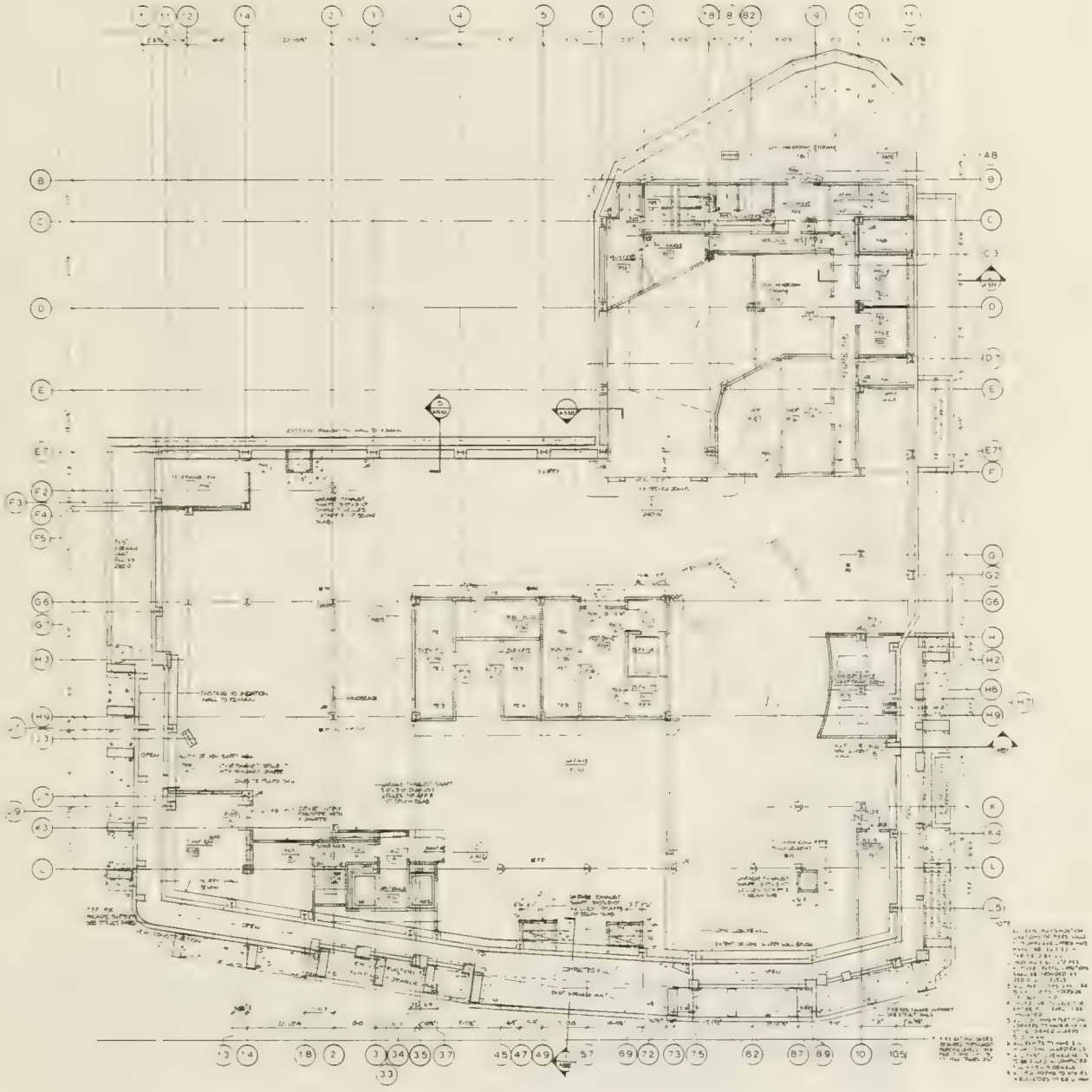


FIGURE 3.14 PROPOSED NEW CONSTRUCTION - PARKING LEVEL ONE

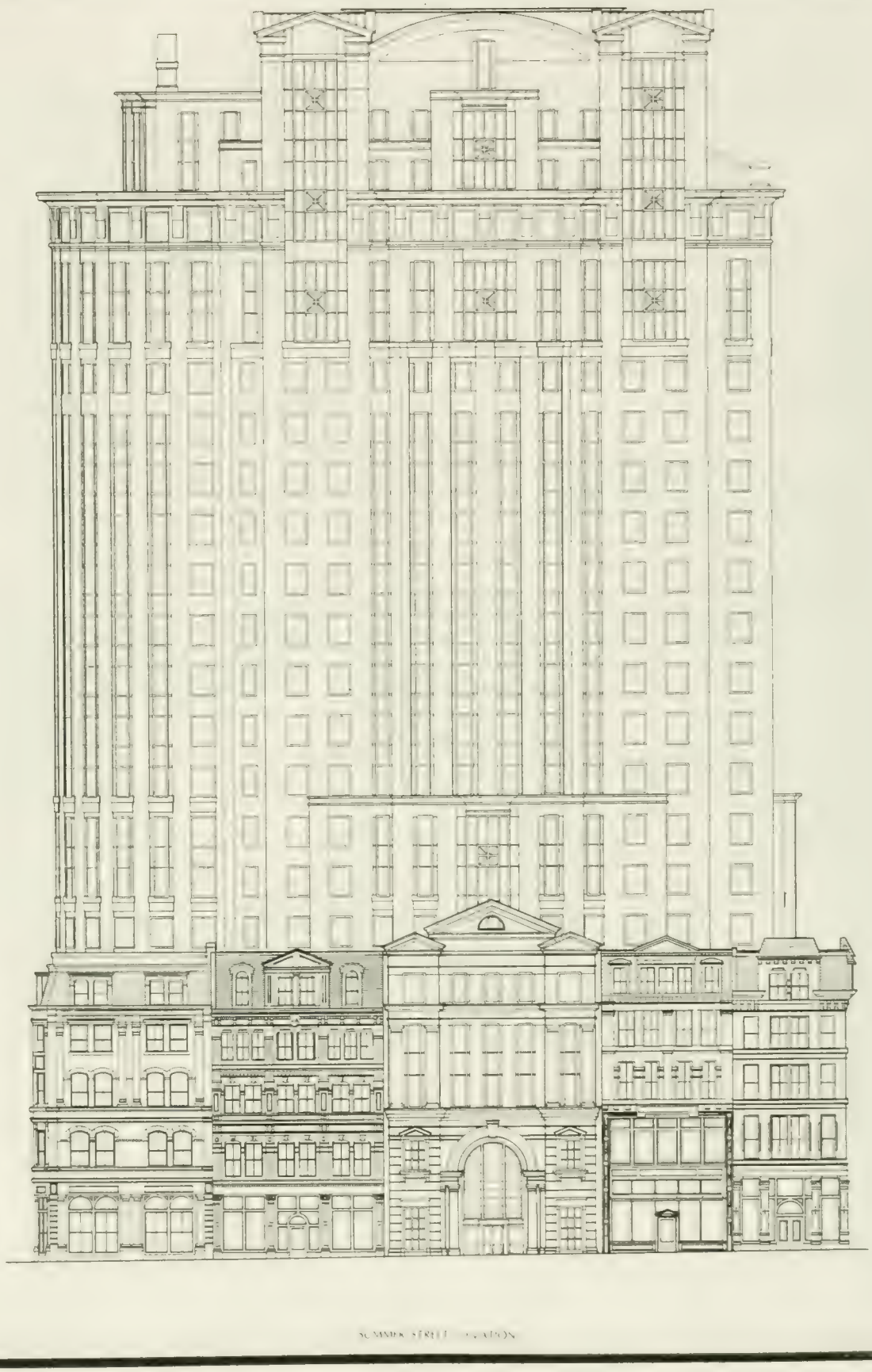


FIGURE 3.15 PROPOSED NEW CONSTRUCTION - SUMMER STREET ELEVATION

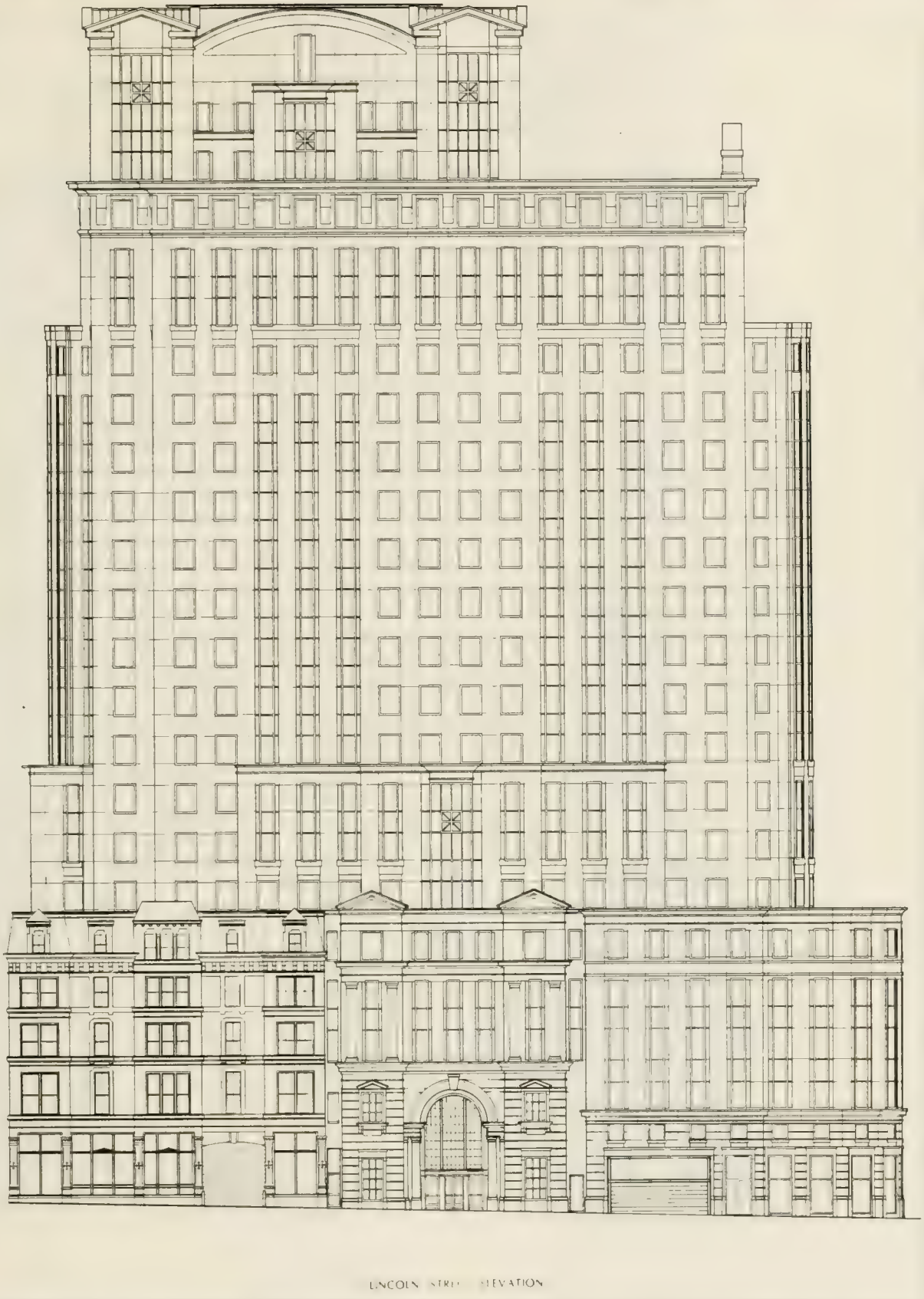


FIGURE 3.16 PROPOSED NEW CONSTRUCTION - LINCOLN STREET ELEVATION

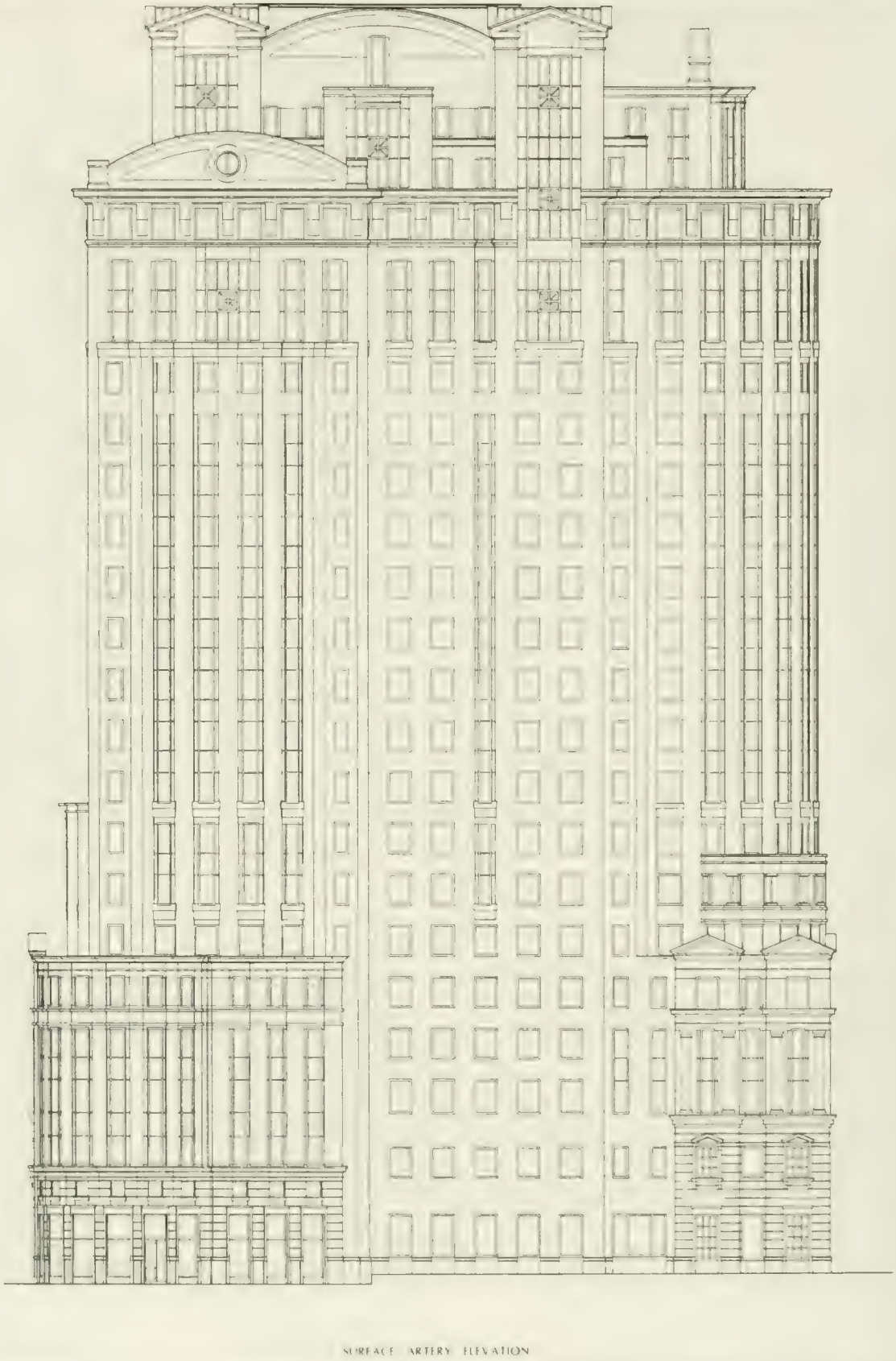
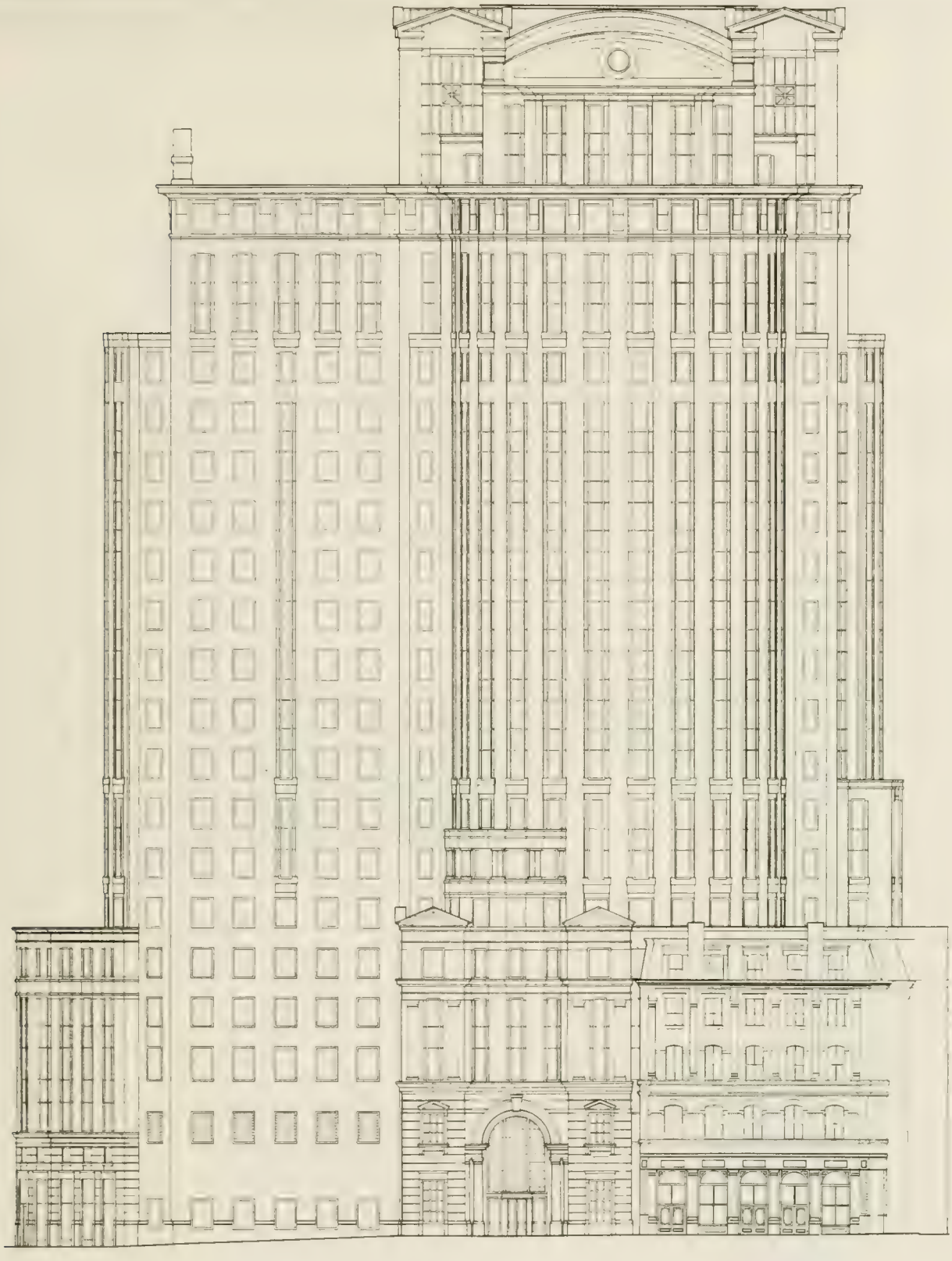


FIGURE 3.17 PROPOSED NEW CONSTRUCTION - SURFACE ARTERY ELEVATION



SOUTH STREET ELEVATION

FIGURE 3-18 PROPOSED NEW CONSTRUCTION - SOUTH STREET ELEVATION

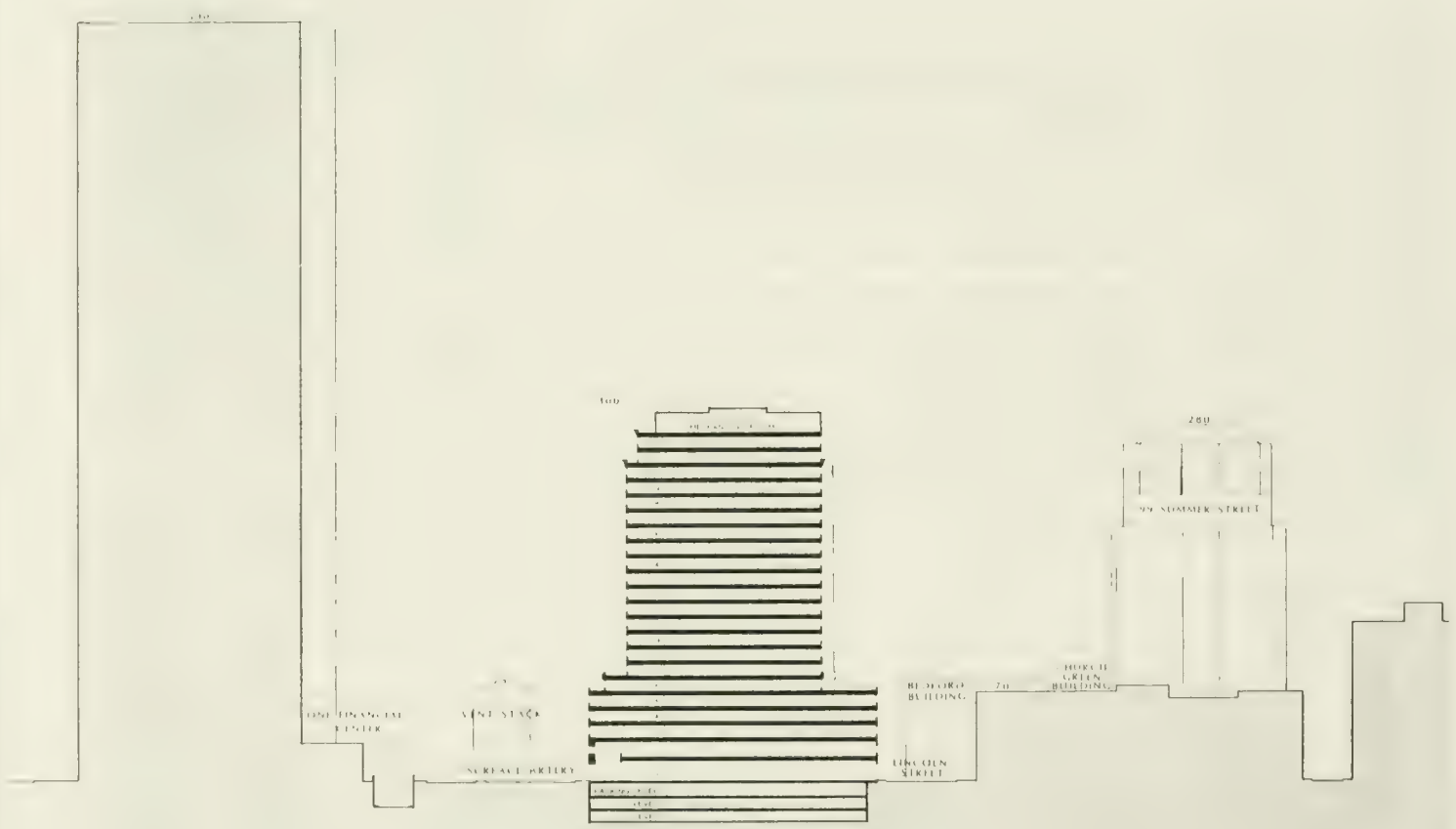


FIGURE 3.19 SITE SECTION LOOKING SOUTHWEST

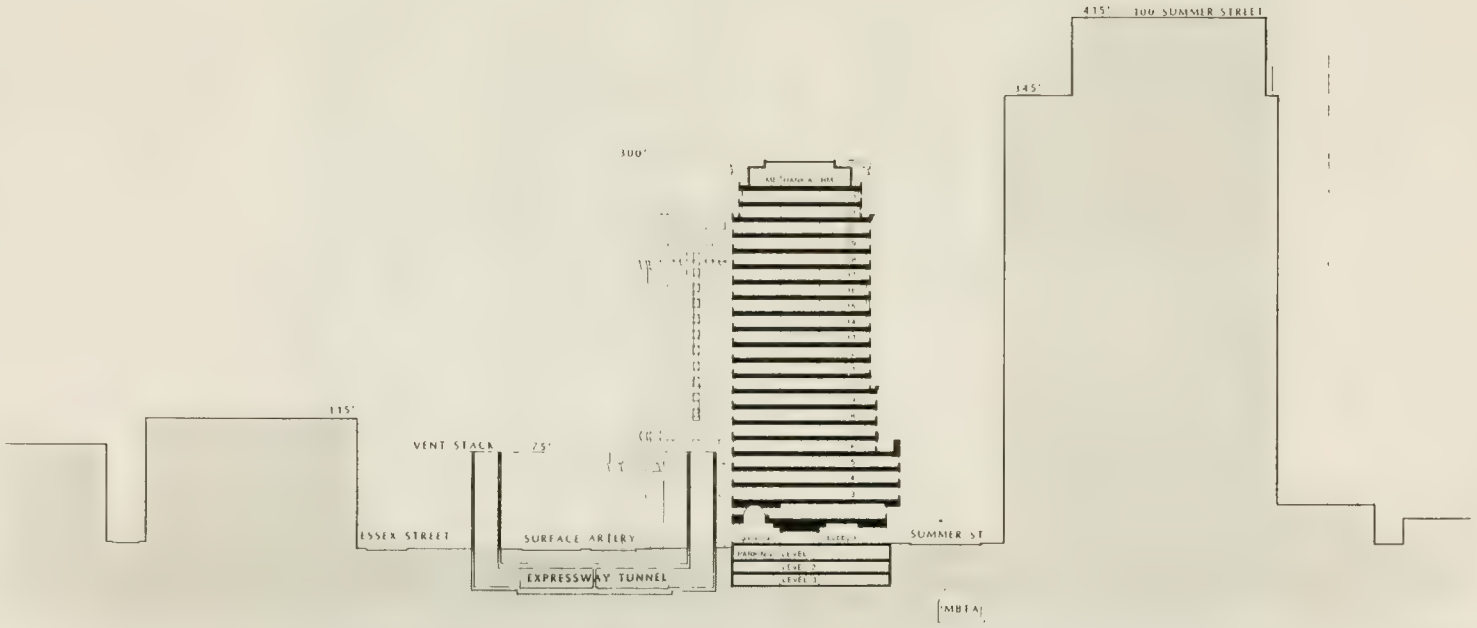


FIGURE 3.20 SITE SECTION LOOKING WEST

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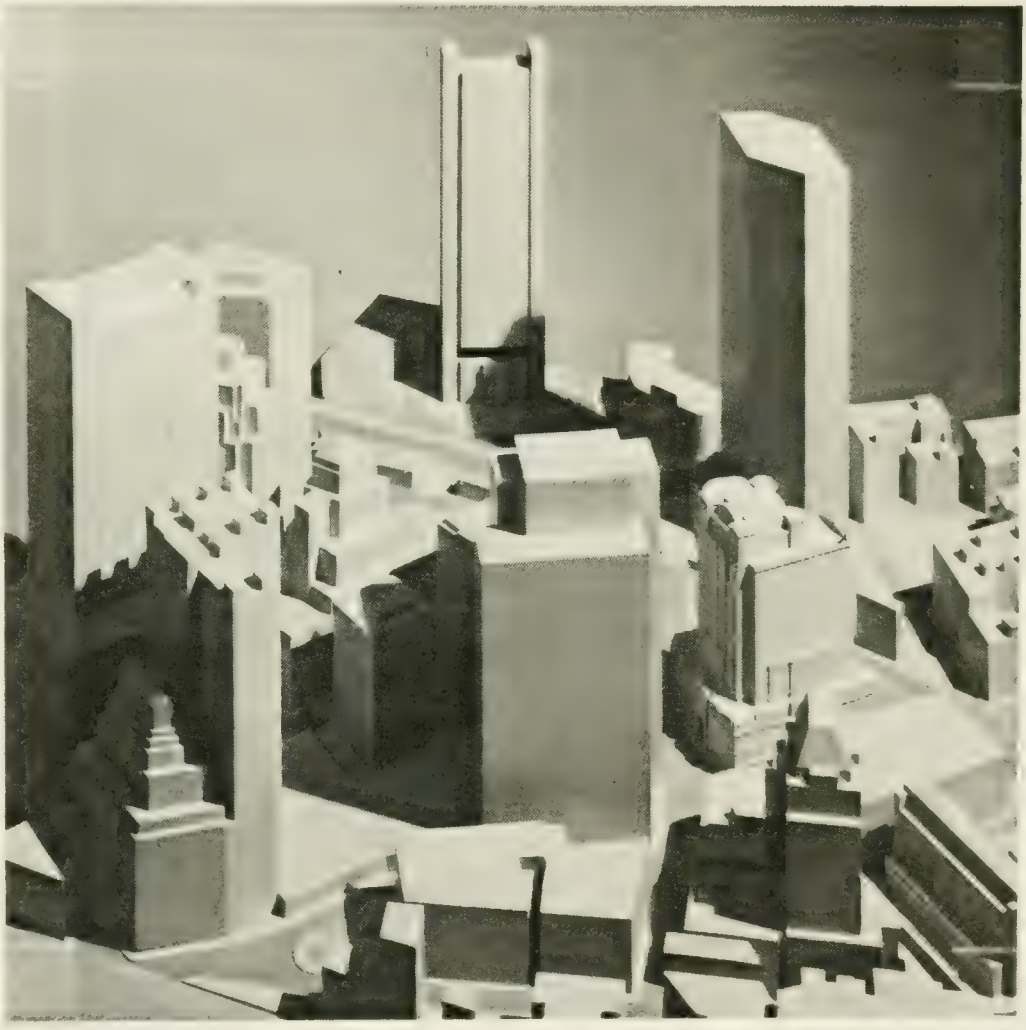

FIGURE 3.21 MODEL PHOTOGRAPH LOOKING SOUTHEAST

4. ENVIRONMENTAL IMPACT STUDIES

4.1 PEDESTRIAN LEVEL WIND IMPACT
TABLE OF CONTENTS

		Page
4.1.1	INTRODUCTION	4.1-2
4.1.2	NATURE OF URBAN WINDS	4.1-2
	4.1.2.1 General	
	4.1.2.2 Boston Wind Climate	
4.1.3	WIND SIGNIFICANCE CRITERIA	4.1-11
4.1.4	QUALITATIVE ANALYSIS	4.1-17
	4.1.4.1 Introduction	
	4.1.4.2 Study Approach	
	4.1.4.3 Qualitative Wind Tunnel Test Results	
	4.1.4.4 Conclusions	
	4.1.4.5 Test Measurement Locations for the Quantitative Analysis	
4.1.5	QUANTITATIVE ANALYSIS	4.1-36
	4.1.5.1 Introduction	
	4.1.5.2 Methods	
	4.1.5.3 Evaluation by the BRA Criteria	
	4.1.5.4 Evaluation by the Melbourne Criteria	
	4.1.5.5 Mitigating Measures	
	4.1.5.6 Conclusions	

4.1.1 Introduction

This chapter documents wind tunnel modeling studies for the new building to be constructed at 125 Summer Street in Boston, Massachusetts. The chapter consists of this introduction and five more sections and a technical appendix. Section 4.1.2 is a brief description of the nature of urban winds. It provides a basis for understanding the various means for modifying the urban wind environment. Section 4.1.3 introduces the wind significance criteria used throughout the report. The criteria are used as a yardstick for measuring windiness and potential impacts. Section 4.1.4 outlines the first phase of wind studies. These are the qualitative flow visualization studies. The qualitative studies were undertaken to discover the general wind flow patterns with and without the new building. The qualitative studies were used to pick study locations for hot wire anemometers in subsequent tests. The heart of the report is Section 4.1.5, the quantitative analysis. This section describes both existing and future wind conditions and compares them to the wind significance criteria. Study methodology, potential for mitigating measures and general conclusions are included in this last section.

4.1.2 Nature of Urban Winds

4.1.2.1 General

The winds blowing over the earth's surface are slowed and mixed by interaction with trees, buildings, and other features which contribute to "surface roughness." The result of this interaction is that the average wind speeds increase with elevation above the local terrain up to a level called the gradient height (usually 275 to 400 m; i.e., 900 to 1,350 ft.). Above this level, the wind speed is relatively constant and unaffected by the surface development. This region below the gradient height where the surface roughness affects the wind characteristics is known as the atmospheric boundary layer.

In an urban environment there is potential for the natural wind field in the boundary layer to be modified in the following ways as it interacts with obstacles:

a. Vertical deflection of upper level winds towards the ground on the windward side of tall buildings. As winds flow perpendicular to the vertical faces of high rise buildings, pressure gradients are created. Higher pressure is created by the winds of greater velocity nearer the gradient height, with lower pressure near ground level. The pressure gradient deflects the winds of higher velocity, normally associated with higher elevations, down to pedestrian level. High wind speeds at ground level are most pronounced near tall buildings which are surrounded by structures whose heights are low in comparison to the tall building. The flow patterns which typically occur in such situations are illustrated in Figure 4.1-1. In such cases, the highest ground level winds are often found around building corners. This corner flow is usually steady, high-speed wind that gradually drops off to a lower speed farther from the building, but becomes gusty in the process.

b. Channeling of the air stream between buildings. Adjacent buildings facades may cause winds to accelerate as the area available for the approaching wind flow is reduced between the buildings. Channeling increases wind speeds within the channel formed. It also creates likely "hot spots" for increased wind gusts at the corners of the channels.

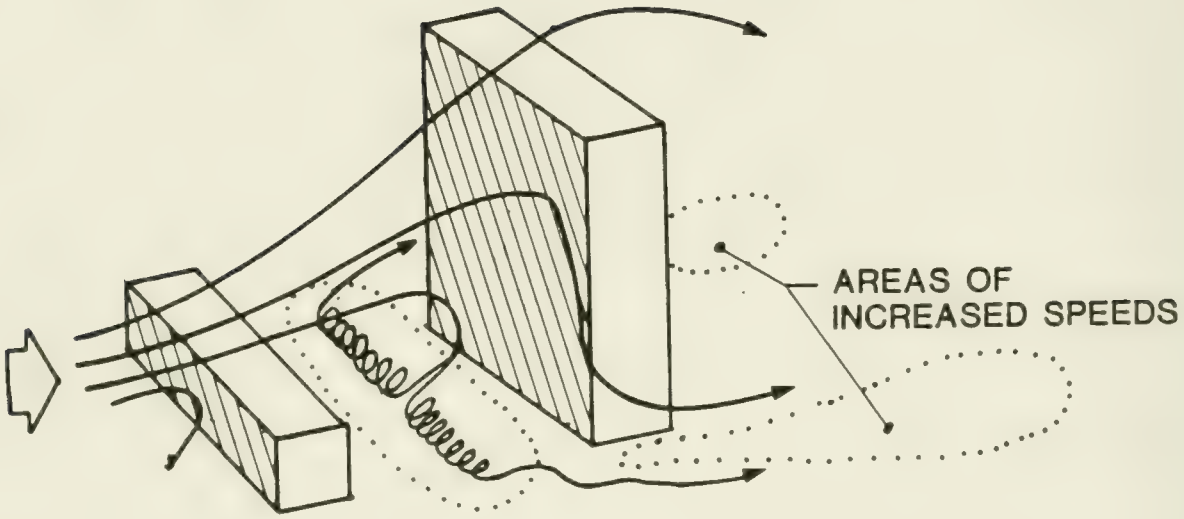

FIGURE 4.1-1 TYPICAL FLOW PATTERNS BETWEEN HIGH AND LOW RISE BUILDINGS

c. Induced turbulence on the leeward side of buildings. As winds flow perpendicular to urban street canyon sections vortexes are created. This results in some potential for increased winds swirling in a vertical plane roughly parallel to the prevailing wind direction (see Figure 4.1-1). Increased winds may occur in eddys on both the windward and lee sides of the street canyon downwind of a building.

The area downwind of a building taller than the next downwind obstruction (building) is usually characterized by a low mean velocity and high turbulence levels. The net result in such a downwind region is a "sheltering" effect.

4.1.2.2 Boston Wind Climate

The significance of the siting with respect to frequently occurring wind events is illustrated in Figures 4.1-2 to 4.1-6, in which the annual and seasonal wind statistics for a reference elevation of 960 feet over Boston are shown on a location plan of 125 Summer Street.

The data in Figures 4.1-2 to 4.1-6 include probability-of-direction wind statistics (dotted line) and probability-of-velocity exceedance curves (solid lines) for the reference level winds, in 3^{o} graduations of wind azimuth. A representation of the scales is presented in Table 4.1-1:

TABLE 4.1-1

Scale Applicable to:	PAZ (Probability that winds will originate from 3° azimuth segment shown)	P(U)Probability that winds will exceed velocity when winds blow from direction shown)
1) inner ring	0.01 (1%)	10 m/s (22.5 mph)
2) middle ring	0.02 (2%)	20 m/s (45 mph)
3) outer ring	0.03 (3%)	30 m/s (67.5 mph)

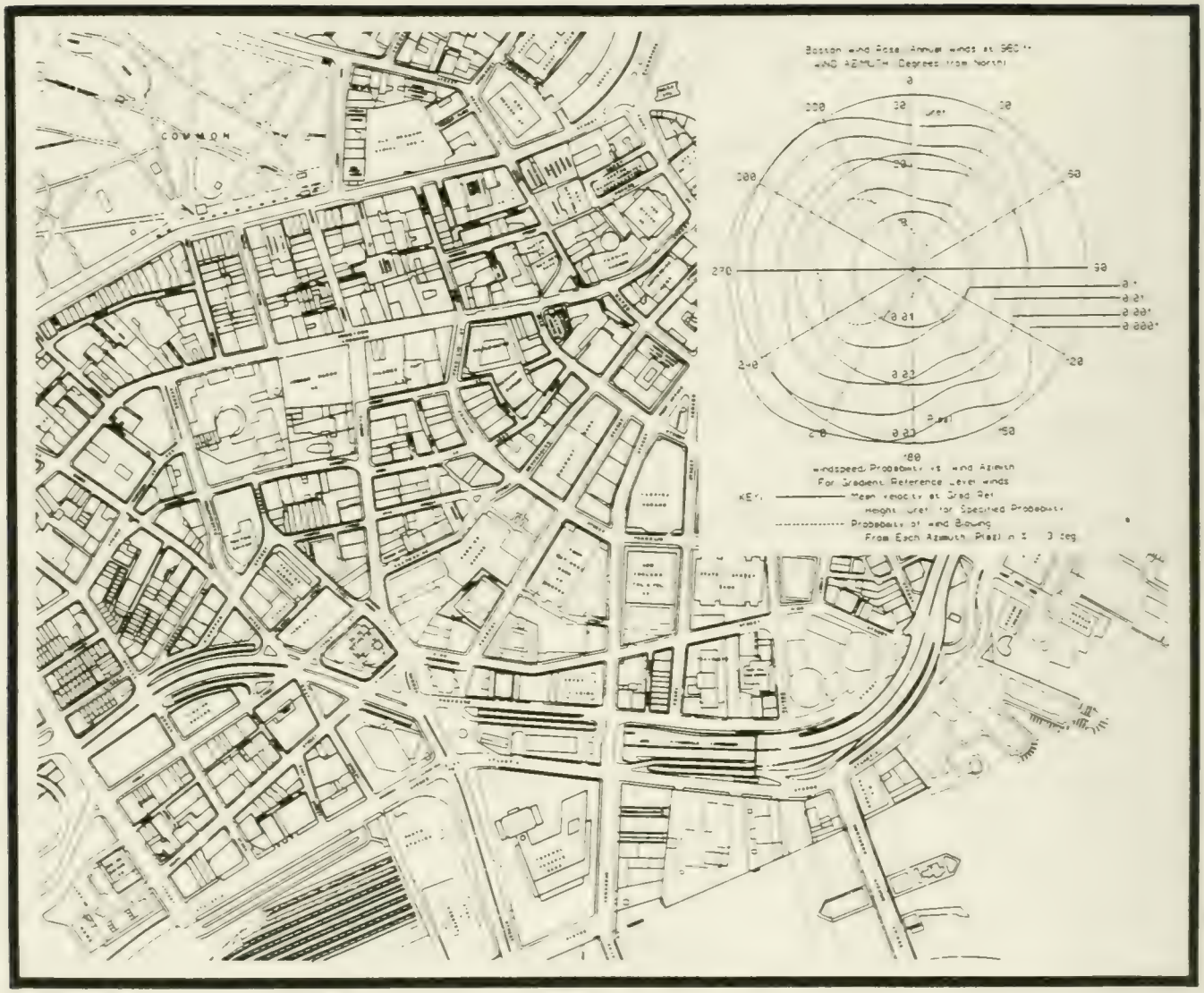

FIGURE 4.1-2 ANNUAL WIND ROSE

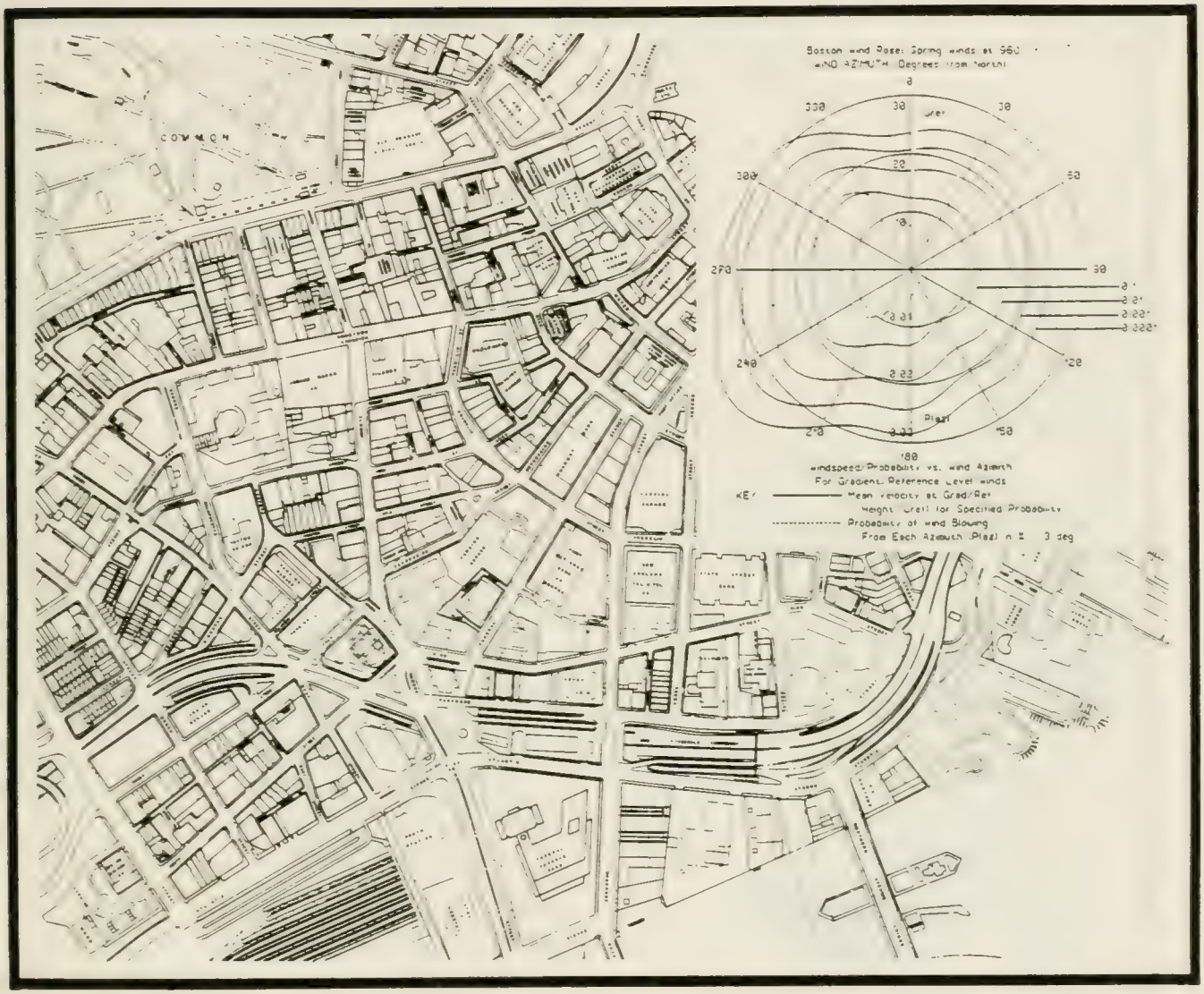
COMMON
Boston wind Rose: Spring winds at 960
WIND AZIMUTH Degrees from North
windspeed/Probability vs. wind Azimuth
For Gradient Reference Level winds
Mean velocity at Grad/Ref
Height Crest for Specified Probability
Probability of wind Blowing
From Each Azimuth (Plot) in 3 deg

FIGURE 4.1-3 SPRING WIND ROSE

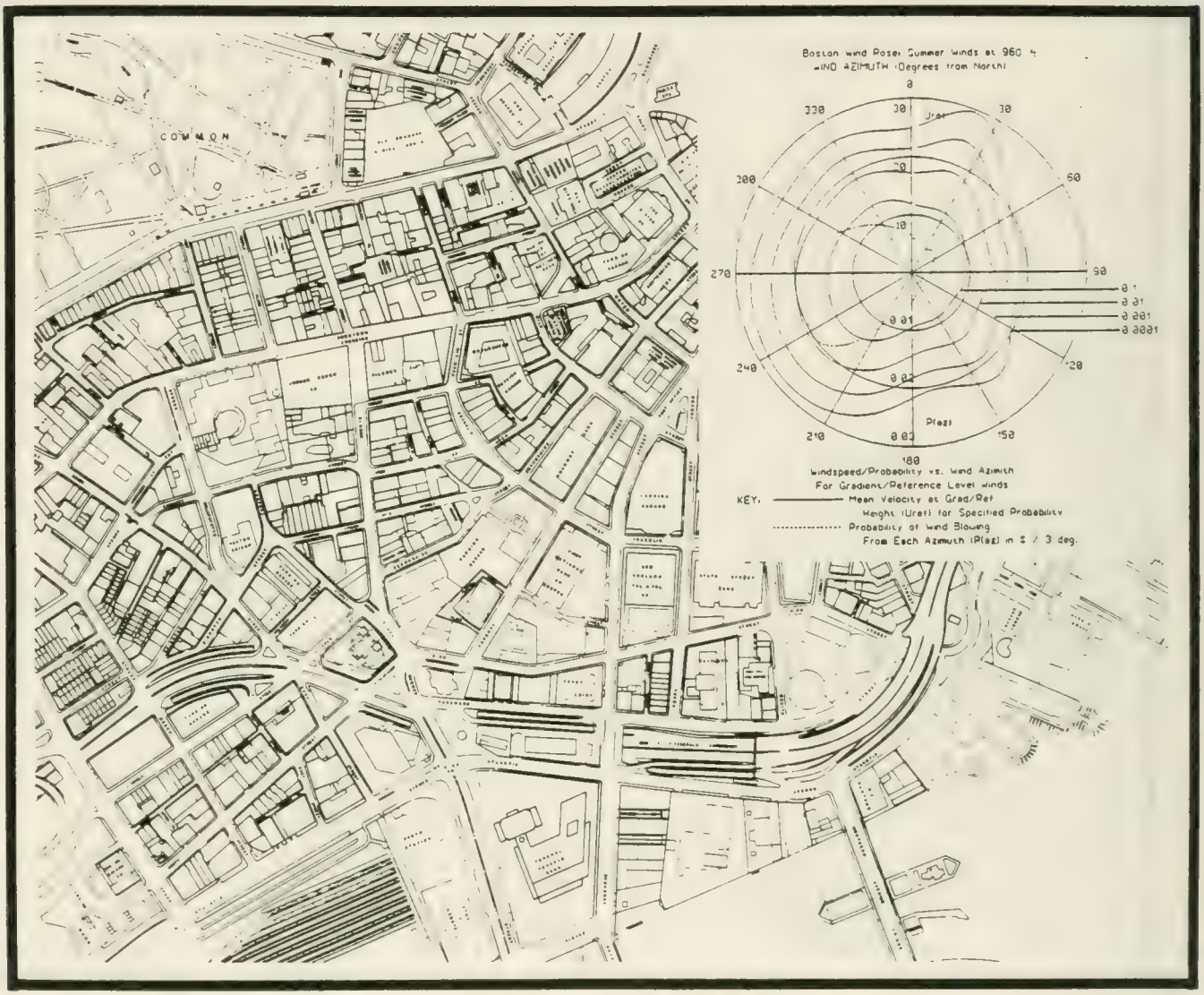

FIGURE 4.1-4 SUMMER WIND ROSE

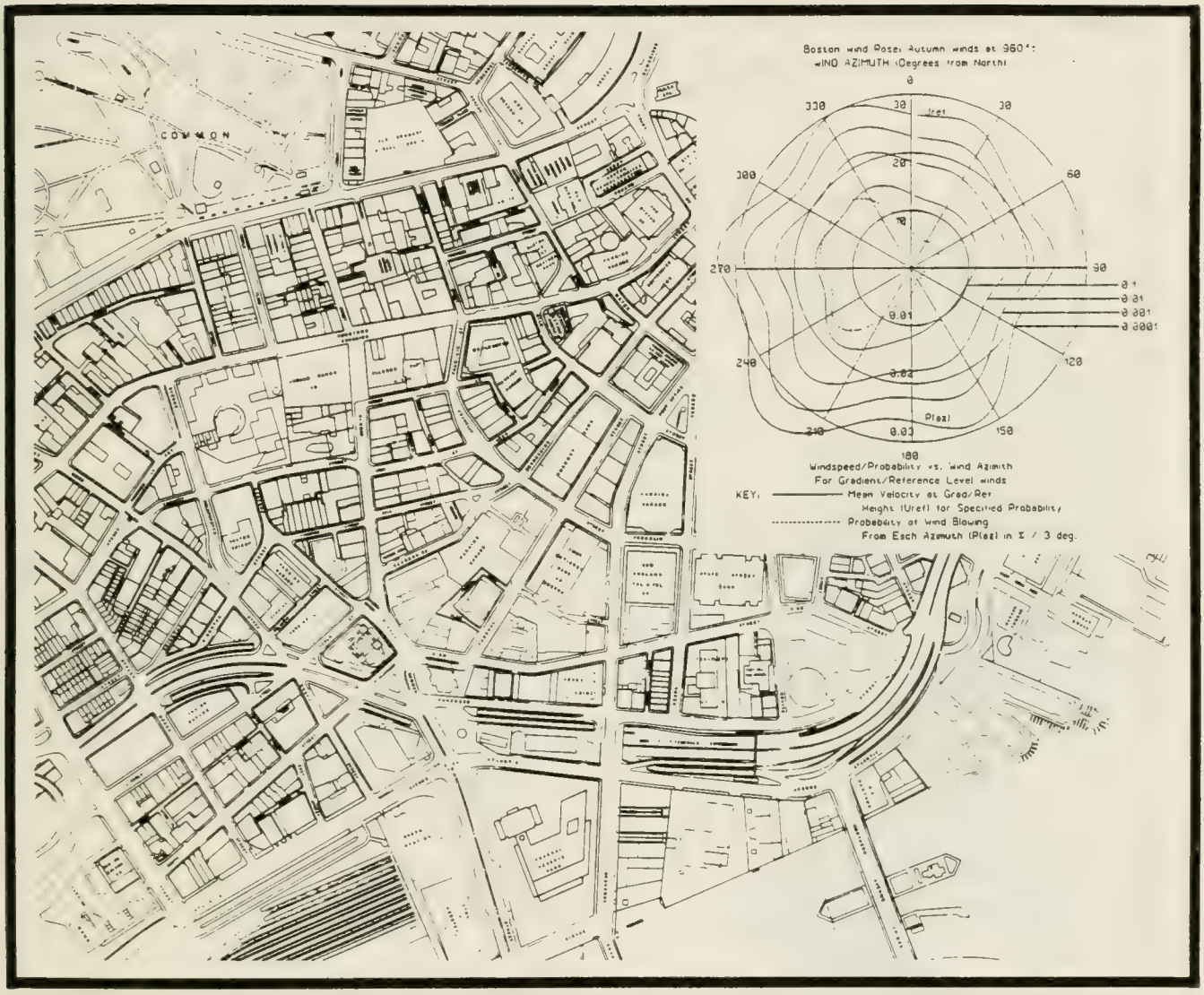

FIGURE 4.1-5 AUTUMN WIND ROSE

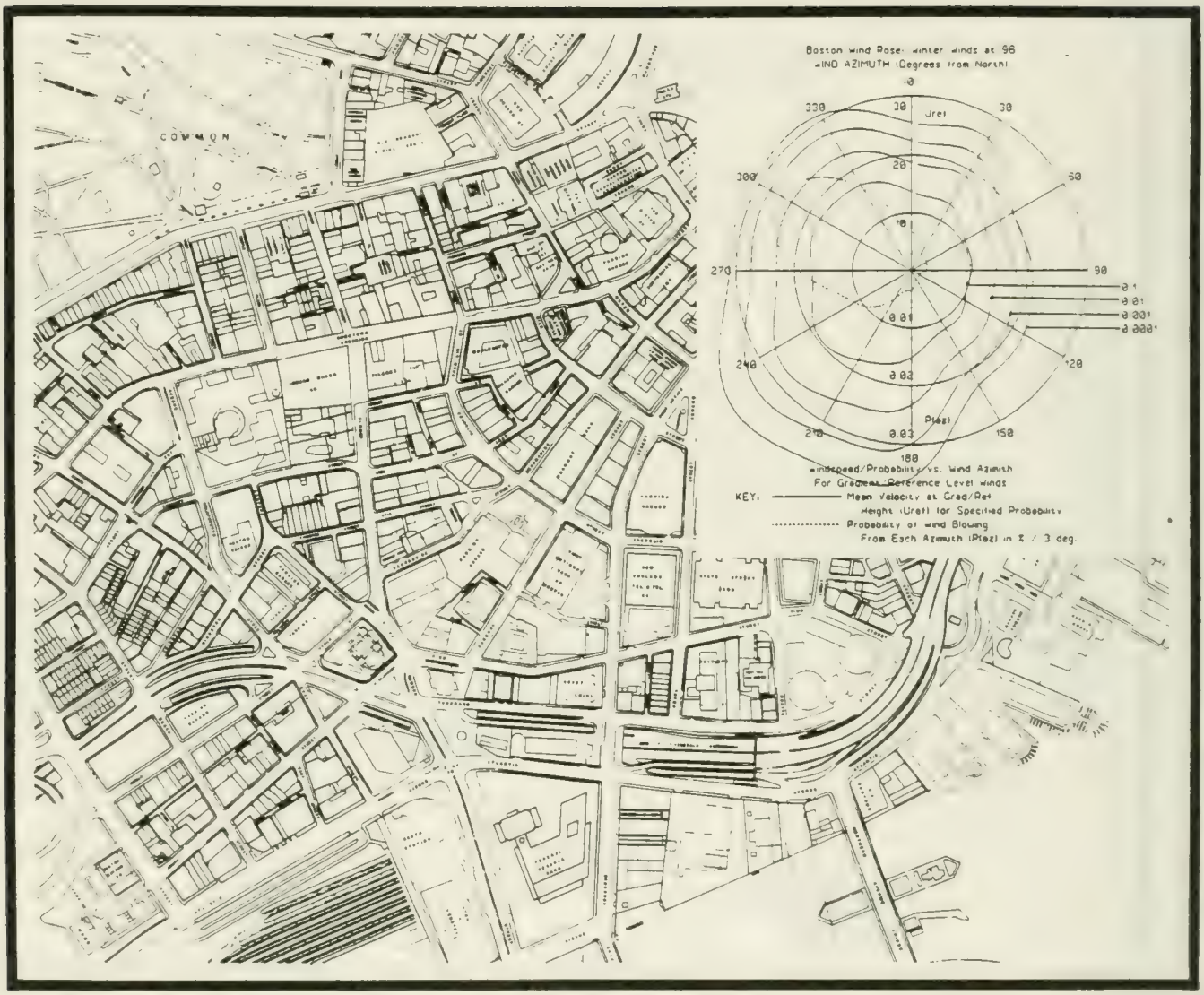

FIGURE 4.1-6 WINTER WIND ROSE

On these plots, the dashed line represents the probability that the wind will originate from a particular 3° azimuthal segment, and the solid contours are lines of equal probability-of-exceedance of various wind speeds to be expected when the winds blow from a given direction. On each "wind rose," the four solid contours start with the inner contour of P=0.1 (10% probability of exceedance) and progress outward to a contour of probability P=0.0001 (.01% probability of exceedance). For example, referring to the wind rose in Figure 4.1-2 (Annual Winds), there is an annualized probability of P=0.017 (1.7%) that the winds will blow from the 3° azimuthal segment centered on 270°), there is a 10% probability (P=0.1) that the mean wind speed at the 960 ft reference height will exceed 16.5 m/s, a 1% probability (P=0.01) that the mean wind speed will exceed 23.0 m/s, a .1% probability (P=0.001) that the mean wind speed will exceed 28 m/s, and a .01% probability (P=0.0001) that the reference level mean wind speed will exceed 32.0 m/s. When used in conjunction with wind tunnel measurements of pedestrian level wind velocities (which are usually normalized to form a ratio of ground level wind velocity-to-reference level mean wind velocity), an annualized (or seasonal) measurement of velocities which will be exceeded a given percentage of time can be derived.

The data in Figures 4.1-2 to 4.1-3 show that the critical wind directions for Boston are generally from the west and northwest.

Winds from other directions must be considered inasmuch as occasional severe impacts may occur, but in terms of optimizing a massing scheme for the project, the direction identified above is predominant.

4.1.3. Wind Significance Criteria

Many different wind engineers have attempted to develop criteria for measuring the significance of various wind speeds. The first credible attempt at developing wind criteria is probably the Beaufort Scale developed by Admiral Beaufort based upon his 19th century observations. Contemporary wind

significance criteria have been suggested by Davenport (1972), Lawson (1973), Penwarden & Wide (1975), Hunt, Poulton & Mumford (1976), Cohen et al (1977) and Melbourne (1978).

The various criteria can often be quite confusing. Some are based upon average wind speeds, others upon wind gust speeds. Some are based upon frequency of occurrence of wind speeds, others are based upon type of activity to be accommodated. Many are based on combinations of these factors. All are influenced by the judgment of the authors and the windiness of the environment to which the authors and their test populations are normally exposed. In short, acceptability of winds, like temperature, may vary considerably from region to region and from person to person.

In Boston, the BRA uses two sets of wind criteria. The first criteria is based on gust velocities and the second on mean wind speeds. The first, and primary criterion, is the BRA wind design guidance level which was derived from several studies but relied most heavily on the Cohen studies, conducted in Boston, in which measured wind speeds were correlated with the observed response of the pedestrian population in the downtown area. The BRA requires that effective gust velocities (defined as average hourly wind speeds + 1.5 root-mean-square) exceeded 1% of the time should be 31 mph (or 13.8 mps). This criterion was selected as the primary criterion since it reflects local perceptions of acceptable wind levels, and because it is a relatively straight-forward, easily interpreted design guideline. This criterion has also been applied by BRA in all wind studies for tall buildings in Boston over the past several years. This criterion has typically been applied for design guidance rather than as an absolute acceptability measure. The BRA has asked prospective developers to explore mitigating measures for designs which are predicted to exceed this design guidance criterion.

The supplementary criteria that is used by the BRA are the Melbourne "International Pedestrian Comfort Criteria" depicted in Figure 4.1-7. These are probablistic criteria for hourly average pedestrian winds for a variety of human activities. The vertical scale is the average hourly velocity in miles per hour; the horizontal scale is the frequency of occurrence of the wind speed. The four curves on the graph separate five comfort zones. The upper zone represents hazardous wind speeds, the second zone indicates wind speeds that may be safe but uncomfortable for walking, the third zone indicates comfortable walking environment; the fourth zone indicates wind speeds low enough to accommodate short term stationary exposures, and the fifth and final zone indicates wind speeds acceptable to accommodate long-term stationary activities. As points of references two additional features have been added to the graphical representation of the Melbourne criteria. One is the BRA criterion, adjusted to approximate mean wind speed rather than an effective gust velocity (i.e., U + 1.5 RMS @ 31 mph = U @ 23 mph*).

The BRA gust velocity criterion fits within the bottom of the second Melbourne zone - safe but uncomfortable for walking. The second feature added to the graph is the dotted curve representative of average wind speed data observed at Logan Airport. This curve also fits within the "safe but uncomfortable for walking" zone, just below the BRA gust velocity criterion. Wind speeds above the dotted line indicate conditions in which urban design elements have <u>increased</u> wind levels; levels below the dotted line indicate that urban landscape features have <u>reduced</u> ambient wind levels. Boston is an extremely windy city. Small changes in the natural wind caused by new construction can result in exceedances of the BRA gust velocity criterion or even the hazardous wind levels suggested by the Melbourne International Pedestrian Comfort Criteria.

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* U/U_{inf} = 0.45 and U_{rms}/U_{inf} = 0.11

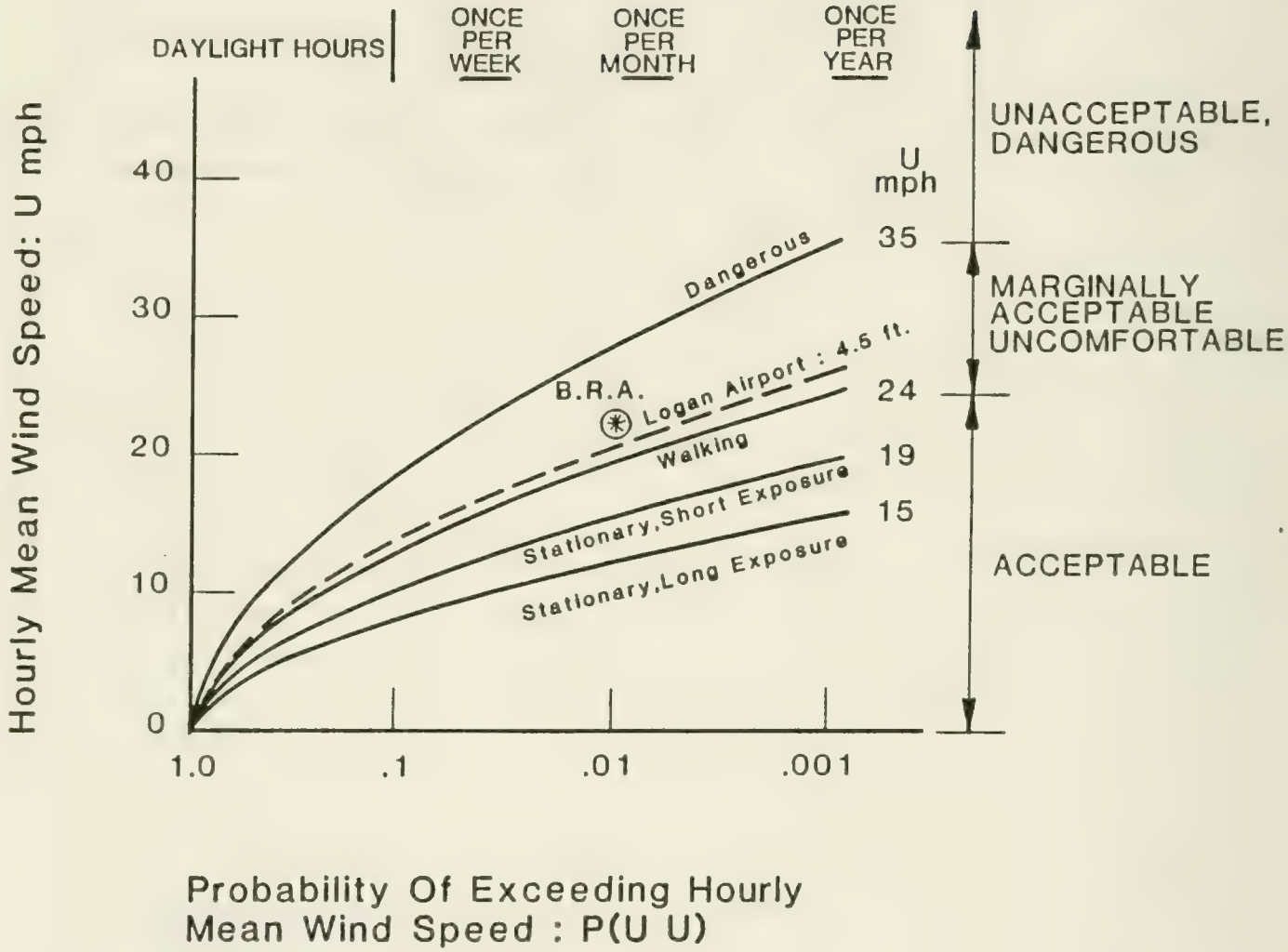

FIGURE 4.1.7 MELBOURNE'S CRITERIA FOR AVERAGE HOURLY PEDESTRIAN WINDS COMPARED WITH OTHER REFERENCES

Accordingly, care must be taken in applying the wind significance criteria, and in interpreting the significance of wind levels in Boston. One additional method which we use repeatedly is to compare existing conditions to those that occur with the new building. In our quantitative studies, we first measure, in the lab, the winds without the new building. Next, we measure the winds with the building. Such measurements are repeated at many points in the vicinity of the new building. We then look at the assembly of test points and determine if, on the average, the new building increases or reduces the ground level winds.

4.1.4 Qualitative Analysis

4.1.4.1 Introduction

The qualitative analysis involved visually observing wind flow patterns associated with 125 Summer Street utilizing a smoke tracer. The objectives of the analysis were as follows:

1) Provide general conclusions on the nature of the wind environment in the project site area.

2) Describe, qualitatively, the nature and locations of project-related changes in the wind environment.

3) Compare the wind environment at the 125 Summer Street site to wind conditions adjacent to other buildings in Boston.

4) Provide information for selecting study locations for the Quantitative Analysis which details wind impacts in absolute terms.

These objectives were accomplished through visual observations of "smoke testing" in the wind tunnel under a variety of wind speeds and directions. A photograph of the model used in these tests is given in Figure 4.1-8.

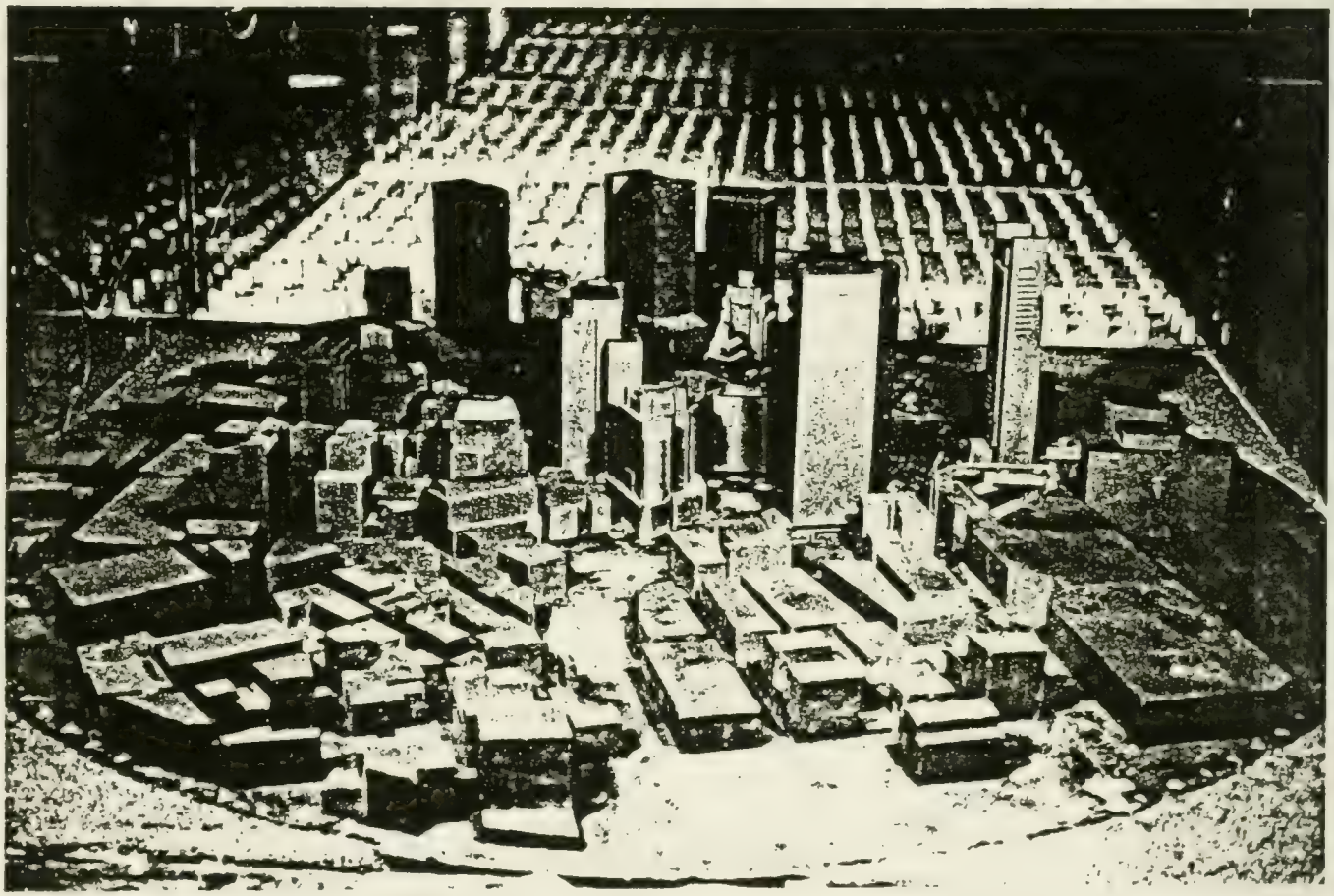

FIGURE 4.1.8 PHOTOGRAPH OF WIND TUNNEL MODEL FOR 125 SUMMER STREET TESTS

4.1.4.2 Study Approach

Pedestrian level winds associated with the proposed 125 Summer Street building were visually studied in the Boston University wind tunnel. This boundary layer wind tunnel is the facility formerly owned and operated by Bolt Beranek and Newman, Inc. It has been used for previous wind studies at several Boston sites including 101 and 150 Federal Street Buildings.

The boundary layer tunnel is 60 feet long, with a cross section of 6 feet by 8 feet. Turntables are mounted in the floor to allow for the placement of scale models mounted on an 8 foot diameter disk. A diagram of the tunnel is provided in Figure 4.1-9.

The wind tunnel is specifically designed to model atmospheric winds by intaking air between spires at the mouth of the wind tunnel. Surface roughness is simulated by drawing the wind over a long, upwind array of surface mounted blocks. Velocity profiles may be varied by adjusting the spacing of the blocks and spires. Flow rate is controlled by either of two fan arrangements. A pair of smaller, lower power, fixed-speed fans is used for flow visualization studies. Quantitative studies are done with a 2.1 meter diameter, 6 blade constant pitch fan powered by a 30 hp motor with variable speed drive.

A 1/384 scale model of the 125 Summer Street building and its surroundings was built on the 8 foot diameter model disk. The model simulates an area of about 3000 feet in diameter. The model disk includes all existing structures within about 1500 feet of the disk center. It also includes:

i) 150 Federal Street
ii) 101 Federal Street
iii) 99 Summer Street, and
iv) 101 Arch Street

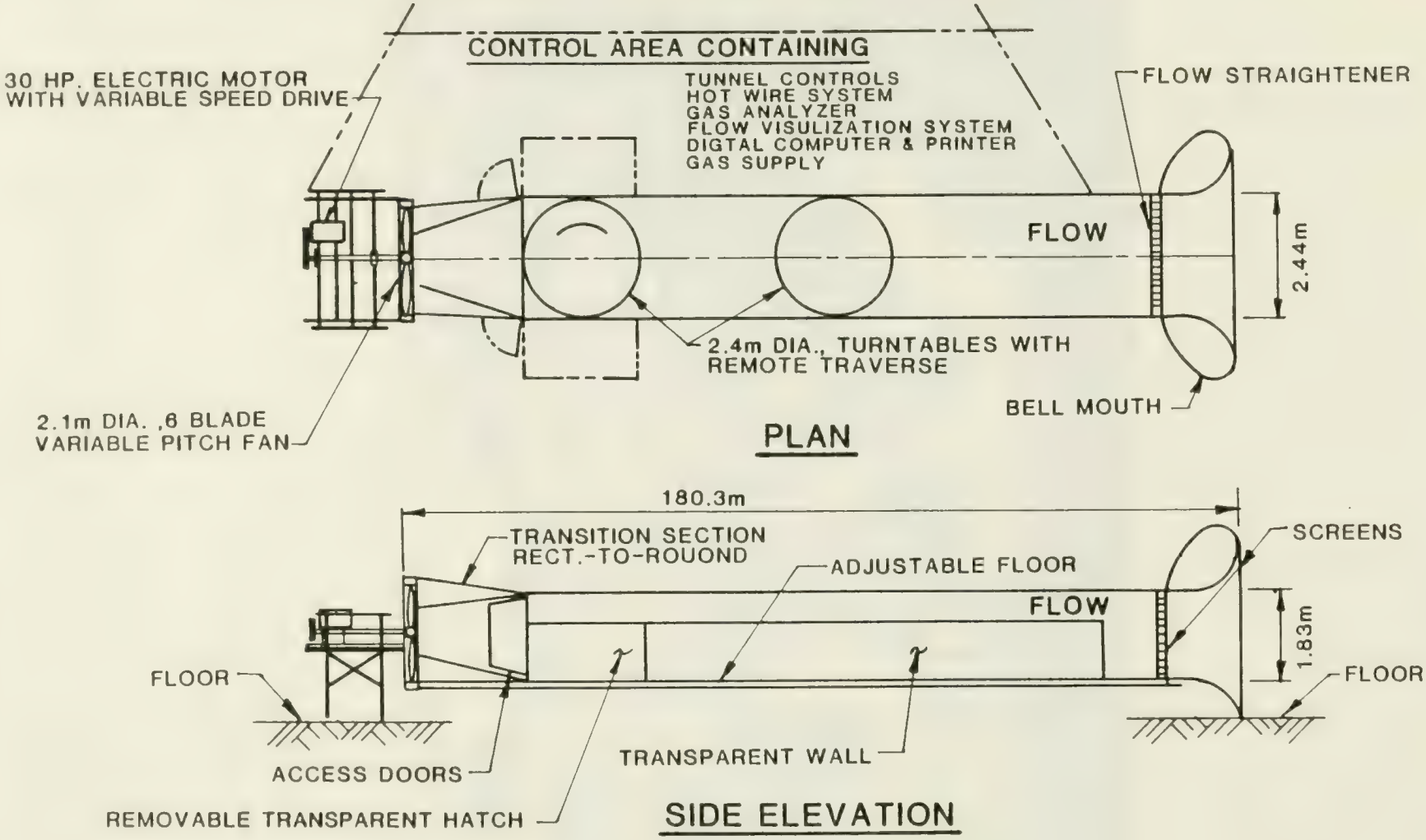

FIGURE 4.1.9 BOSTON UNIVERSITY BOUNDARY LAYER WIND TUNNEL

A smoke tracer was used to provide the flow visualization. The tracer was provided by mounting titanium tetra chloride vials on a movable, hand-held probe. The probe was manipulated, manually, by personnel in the wind tunnel to provide a "smoke" plume at preselected points.

Two iterations of flow visualization testing were undertaken. The first iteration involved extensive viewing of flow patterns associated with winds from each of the eight major compass directions for both the Build and No-Build configurations. This iteration involved carefully moving the smoke probe through the project area, with and without the proposed project, at the points shown in Figure 4.1-10. Wind patterns were observed at and between the points shown. In addition, the probe was moved vertically to examine winds deflected down the face of the proposed project. This iteration was videotaped for subsequent review and analysis and to provide permanent record of the visualization testing.

The second iteration involved a detailed examination of the videotapes. This was undertaken by viewing the uncut original videotapes. These originals provide a quality record of the "smoke testing" and were utilized in selecting study locations for the quantitative analysis.

4.1.4.3 Qualitative Wind Tunnel Test Results

Winds in the project area of the proposed 125 Summer Street building are primarily dominated by existing high-rise structures. The key feature is the 100 Summer Street building opposite the project site to the north. The south facing side of this high-rise, especially towards the southwest corner of the building, is presently recognized as one of the windiest areas in the city. To lesser degrees other nearby high-rise structures also modify the local wind patterns as well. One Financial Center to the southeast, 99 Summer Street to the west, and the Fiduciary Trust Building to the northeast all have some noticeable effects on the winds trajectory along city streets in the project area.

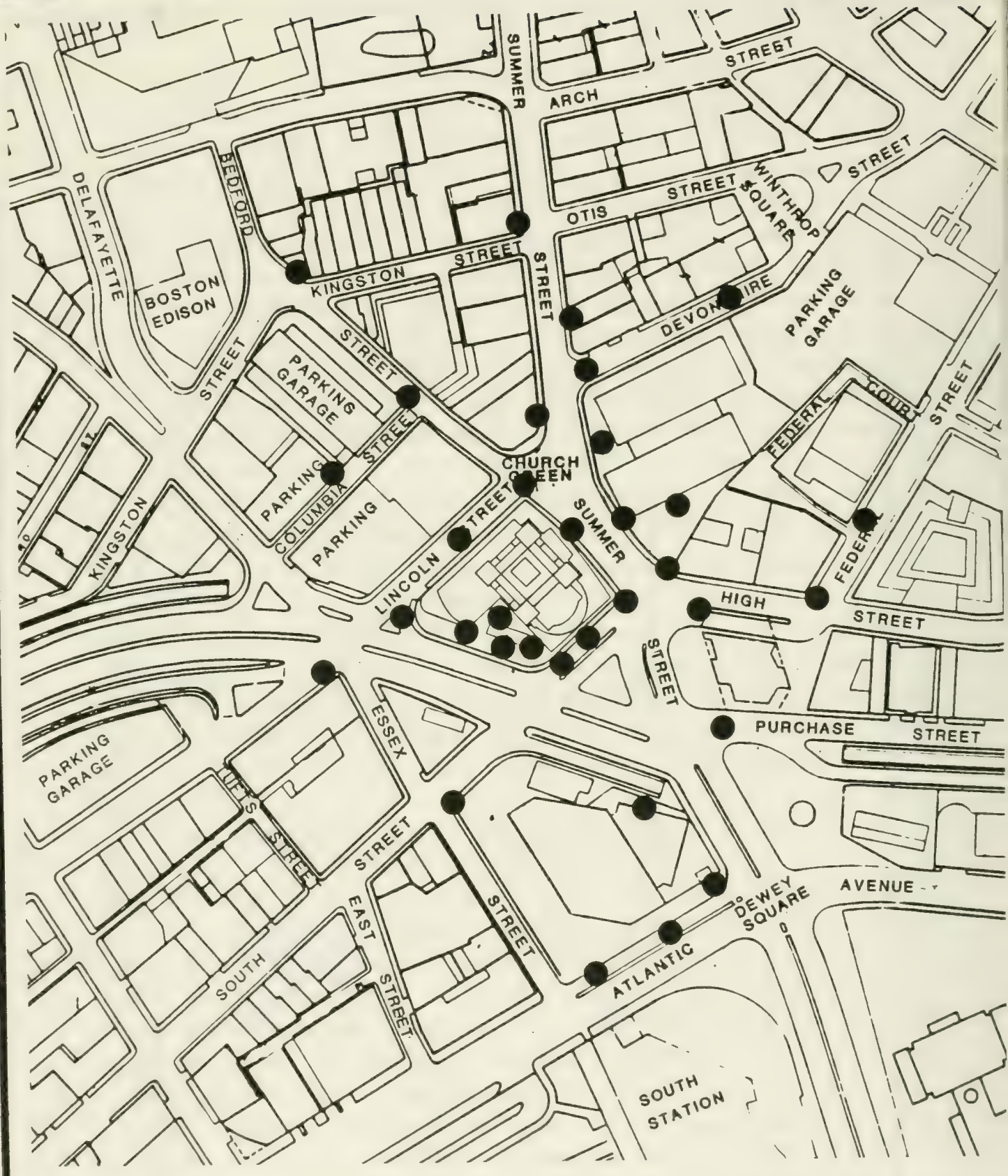

FIGURE 4.1-10 SMOKE TEST STUDY SCHEME

For most wind directions, the addition of 125 Summer Street appears to only effect winds at streets and pedestrian ways directly adjacent to the project site. The dominant effects of nearby taller structures significantly diminishes the proposed project's effects away from its site. The predominant wind feature of the proposed 125 Summer Street building is only its potential for increasing wind speeds at pedestrian ways at groundlevel corners of the project site. Under the existing configuration, for some wind directions, the wind flow pattern at the project site is over the existing buildings. Construction of the tower portion of the proposed project, however, will cause winds to be deflected down its windward face and result in additional flow around its corners as opposed to over the top. The setback (or podium) design of the project's tower, though, aids in mitigating potential groundlevel wind speed increases at pedestrian ways adjacent to the project. Positive effects of the proposed 125 Summer Street building were also noted as the project provides sheltering at Summer Street when winds are from a southerly direction. In addition, the proposed project, in a number of cases, appears to reduce wind flow toward corners of 100 Summer Street by drawing the air stream adjacent to the project site into its own wake region.

The qualitative wind tunnel study of the proposed project provided the following information by wind direction:*

North Wind:

Wind flow patterns in the project area were dominated by the 100 Summer Street building which is north of the project area. The wake of 100 Summer Street at 125 Summer Street was most apparent as winds were accelerated around the southwest corner of this building and drawn up its back side. Winds in this wake area appeared turbulent and of low

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* The Figures 4.1-11 through 4.1-18, present flow patterns associated with construction of the project.

speed. A vertical vortex in the plaza area on the east side of 100 Summer Street was also evident. The primary impact of the project appeared to be some accelerated flow at its northeast and northwest corners. The set back of the tower portion of the project aided in mitigating potential wind levels at these locations. Under both the existing and Build configurations low wind speeds were noted along the south side of the project site near its southwest corner. Under the Build configuration a vertical vortex up the back side of 125 Summer Street was evident.

The flow patterns associated with the north wind conditions and the proposed project in place are depicted in Figure 4.1-11.

Northeast Wind:

Wind flow directly upwind of the project was dominated by the 100 Summer Street and 101 Federal Street buildings. Wind levels in the wake area of 100 Summer Street near the northwest corner of 125 Summer Street were of low speed. Noted windy locations were along the Surface Artery adjacent to the project site under both the No-Build and Build configuration and along Columbia Street near Bedford Street. Under the No-Build configuration winds were channeled along Columbia Street and around the northwest corner of the elevator garage onto Bedford Street. This channeling appeared somewhat diminished with the project as the wake region of 125 Summer Street drew the air stream back away from Columbia Street and vertically upward. Accelerated flow as a result of the project was evident at the northeast, northwest, and southeast corners of the proposed project. Low speeds were noted along Lincoln Street in the wake region of 125 Summer Street. These flow patterns are shown in Figure 4.1-12.

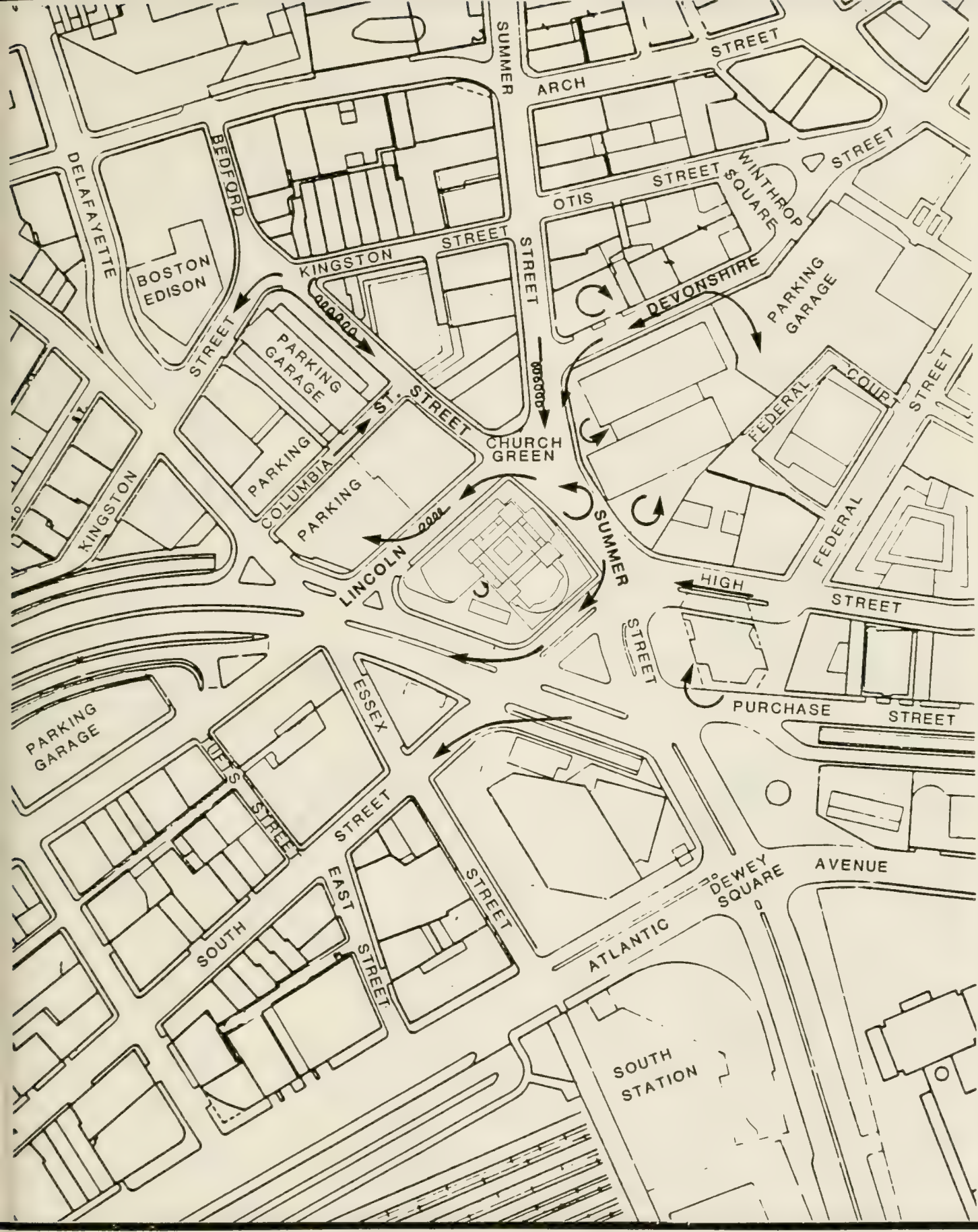


FIGURE 4.1-11 LOCAL WIND FLOW PATTERNS FOR NORTH WINDS

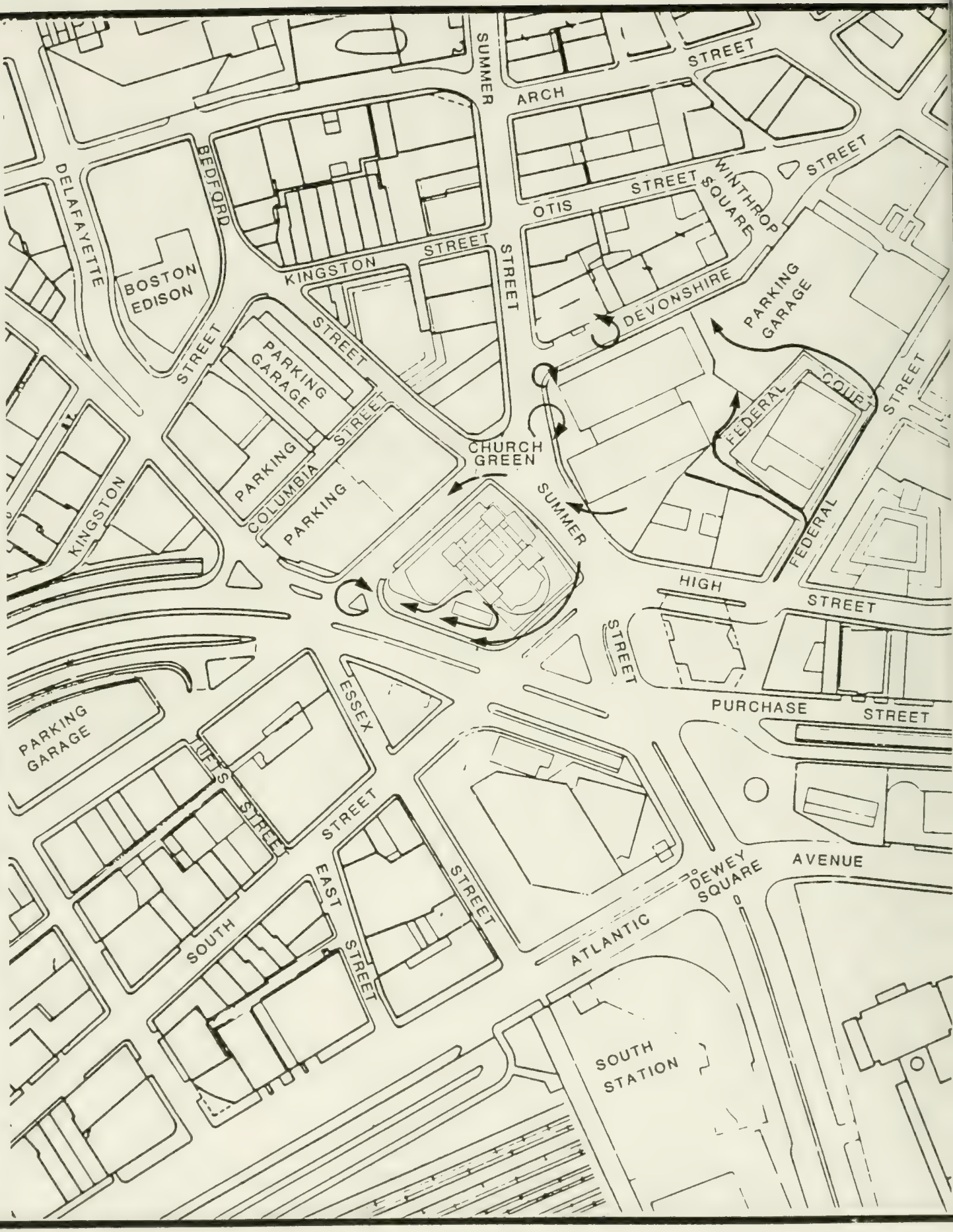


FIGURE 4.1-12 LOCAL WIND FLOW PATTERNS FOR NORTHEAST WINDS

East Wind:

Wind flow patterns for east winds in the project area are presented in Figure 4.1-13. High winds were observed at the Surface Artery south of the project area and along Summer Street as winds are channeled between 100 Summer Street and the project site. Windy conditions were also observed at the southwest corner of 100 Summer Street and along Bedford Street near the southwest corner of 99 Summer Street. Calm conditions as a result of the project's wake were observed on the west side of the project. Accelerated flow around the corners of the proposed building were evident, however, the podium design of the building appears to mitigate the accelerated corner flow to some extent. In addition, the observed flow at the northwest corner of the proposed 125 Summer Street project appears to redirect a portion of the air stream away from the southwest corner of the 100 Summer Street building by drawing it back into its own wake region along Lincoln Street.

Southeast Wind:

Flow patterns around the project site are to some extent affected by the wake region of One Financial Center. Windy conditions were observed at the northeast corner of this high-rise building. To the east of the project site low speeds were observed under the No-Build configuration. Smoke testing demonstrated some accelerated flow along the eastern edge of the proposed building as winds down the windward face of the proposed 125 Summer Street building were accelerated around the southeast and northeast corners. Lower wind speeds were evident in the wake region at the northwest corner of the project, however, accelerated flow at the southwest corner of 100 Summer Street was evident under both the Build and No-Build configurations. Again, a vertical vortex was noted in the

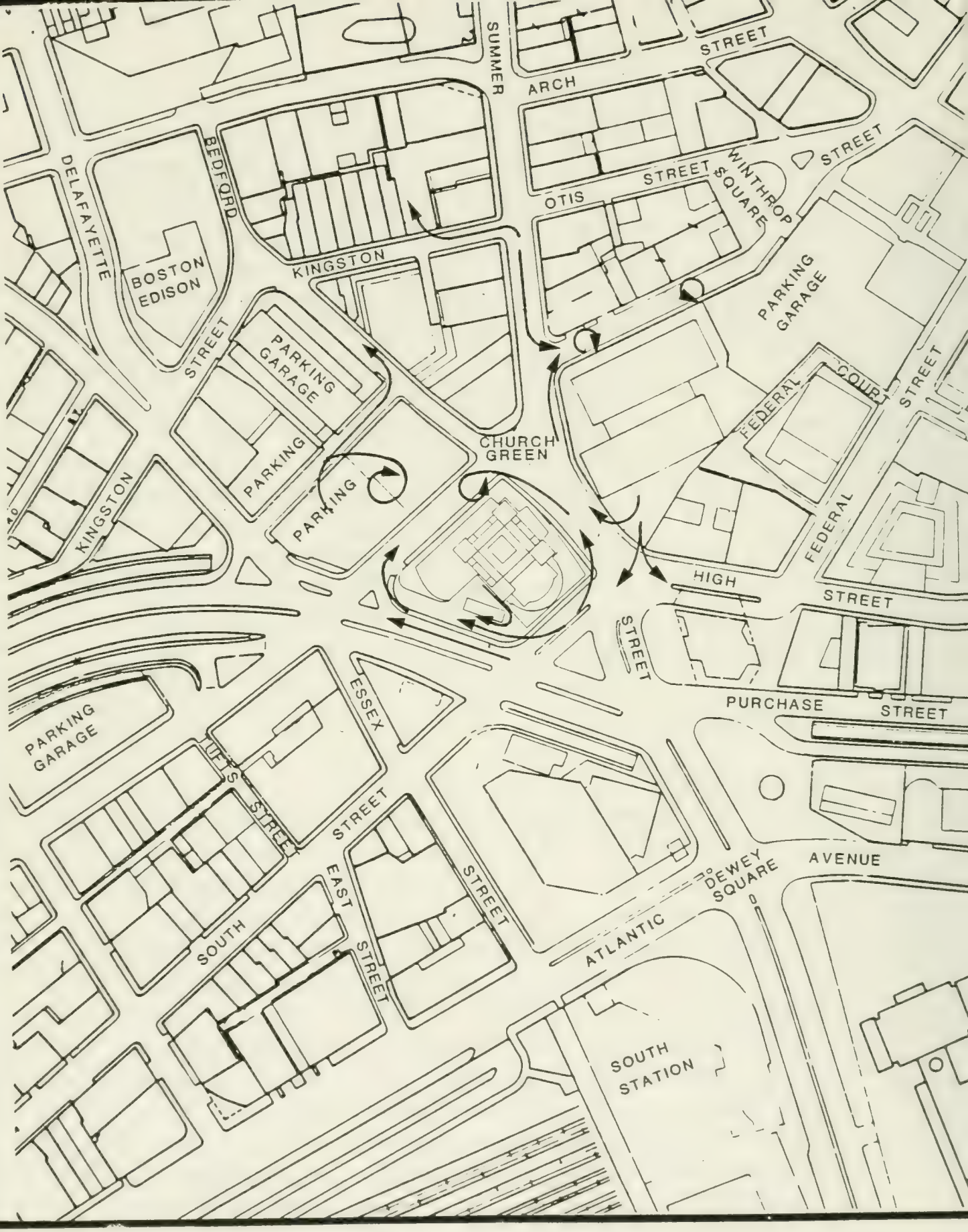


FIGURE 4.1-13 LOCAL WIND FLOW PATTERNS FOR EAST WINDS

plaza area on the east side of the 100 Summer Street building. Low wind speeds were observed in this plaza area, however, at the southeast corner of 100 Summer Street gusty winds were noted. Flow patterns for southeast winds are conceptualized in Figure 4.1-14.

South Wind:

Wind flow patterns associated with a south wind are presented in Figure 4.1-15. Reduced wind speeds along Summer Street in the wake region of the proposed project was one of the most notable features as the air flow was drawn up the back of 125 Summer Street. The project does demonstrate higher wind speeds along its east side, as was also evident under southeast winds. Under the No-Build configuration winds generally pass directly over the existing buildings at the project site. However, the height of the proposed project causes winds to accelerate around the building toward the low pressure area created near building corners. Windy conditions were again observed at the southwest corner of 100 Summer Street. However, potential wind speed reductions were noted along Summer Street due to the presence of the proposed project.

Southwest Wind:

Windy conditions were observed along the south side of the project as the air stream flowed northward along the Surface Artery. Gusty conditions were observed opposite the northwest corner of the proposed project as winds were channeled eastward along Bedford Street and around the southeast corner of 99 Summer Street up along Devonshire Street. Accelerated corner flow was observed at the northwest and southeast corners of the proposed 125 Summer Street building as winds were drawn toward its wake region. However, low speeds were observed along the east

FIGURE 4.1-14 LOCAL WIND FLOW PATTERNS FOR SOUTHEAST WINDS

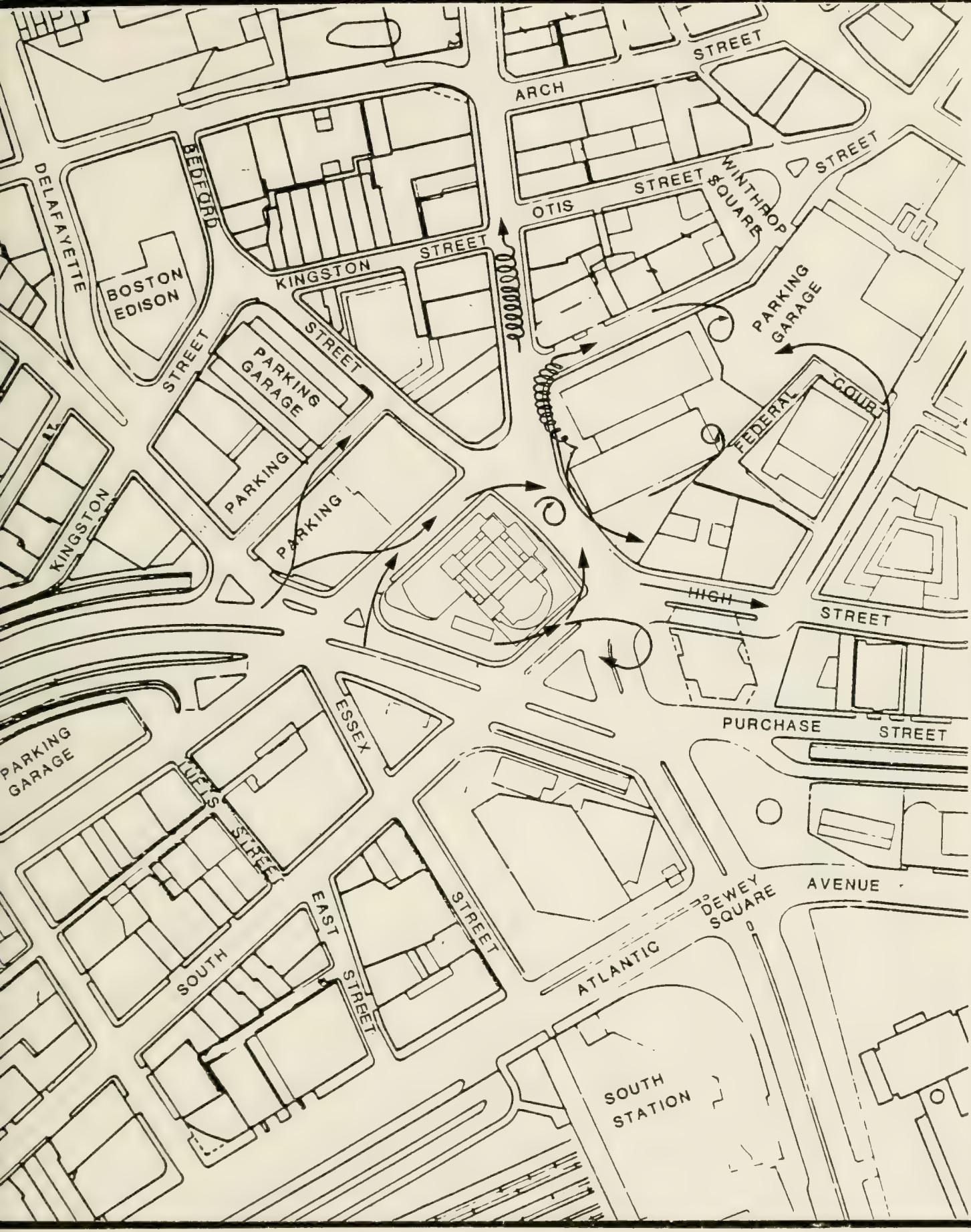


FIGURE 4.1-15 LOCAL WIND FLOW PATTERNS FOR SOUTH WINDS

side of the project in the wake region. Opposite the north side of the project site winds drawn into the plaza area on the lee side of 100 Summer Street flowed up the back of this high-rise structure. Wind flow associated with southwest winds are shown in Figure 4.1-16.

West Wind:

Wind flow patterns in the project area were dominated by the presence of 100 Summer Street and to some degree 99 Summer Street. Windy conditions were observed along the south side of 100 Summer Street. At the 100 Summer Street plaza area (located in the wake region) a very tight vertical vortex was observed up the back side of 100 Summer Street. Low speeds were observed at both Lincoln and Summer Streets adjacent to the project while gusty winds were evident along the south side of the project site near the vent building. Accelerated flow as a result of the project's construction were noted at its northwest and southwest corners. The towers set back, however, aided in mitigating ground level corner flow of winds deflected down its windward face. Flow patterns are depicted in Figure 4.1-17.

Northwest Wind:

The presence of the 100 Summer Street again dominated the wind flow patterns around the project site. Windy conditions were observed at the southwest corner of 100 Summer Street and along Summer Street adjacent to the project site. Low wind speeds were observed in the 100 Summer Street Plaza area and along the south side of the proposed project. Near calm conditions were apparent along the east side of 125 Summer Street in its wake. The podium design of the project appeared to mitigate winds at its northeast corner. Flow patterns under northwest winds are depicted in Figure 4.1-18.

FIGURE 4.1-18 LOCAL WIND FLOW PATTERNS FOR NORTHWEST WINDS

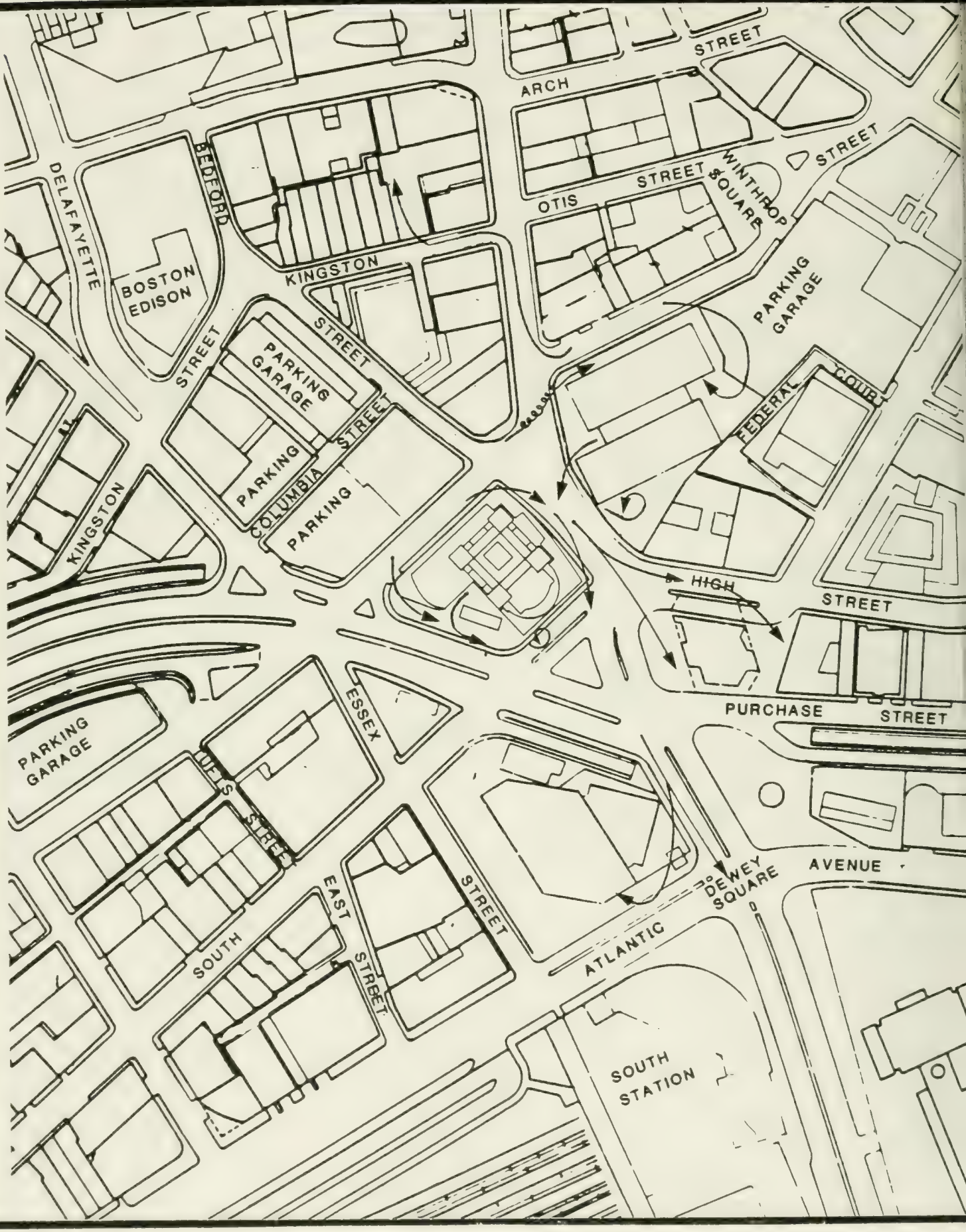


FIGURE 4.1-17 LOCAL WIND FLOW PATTERNS FOR WEST WINDS

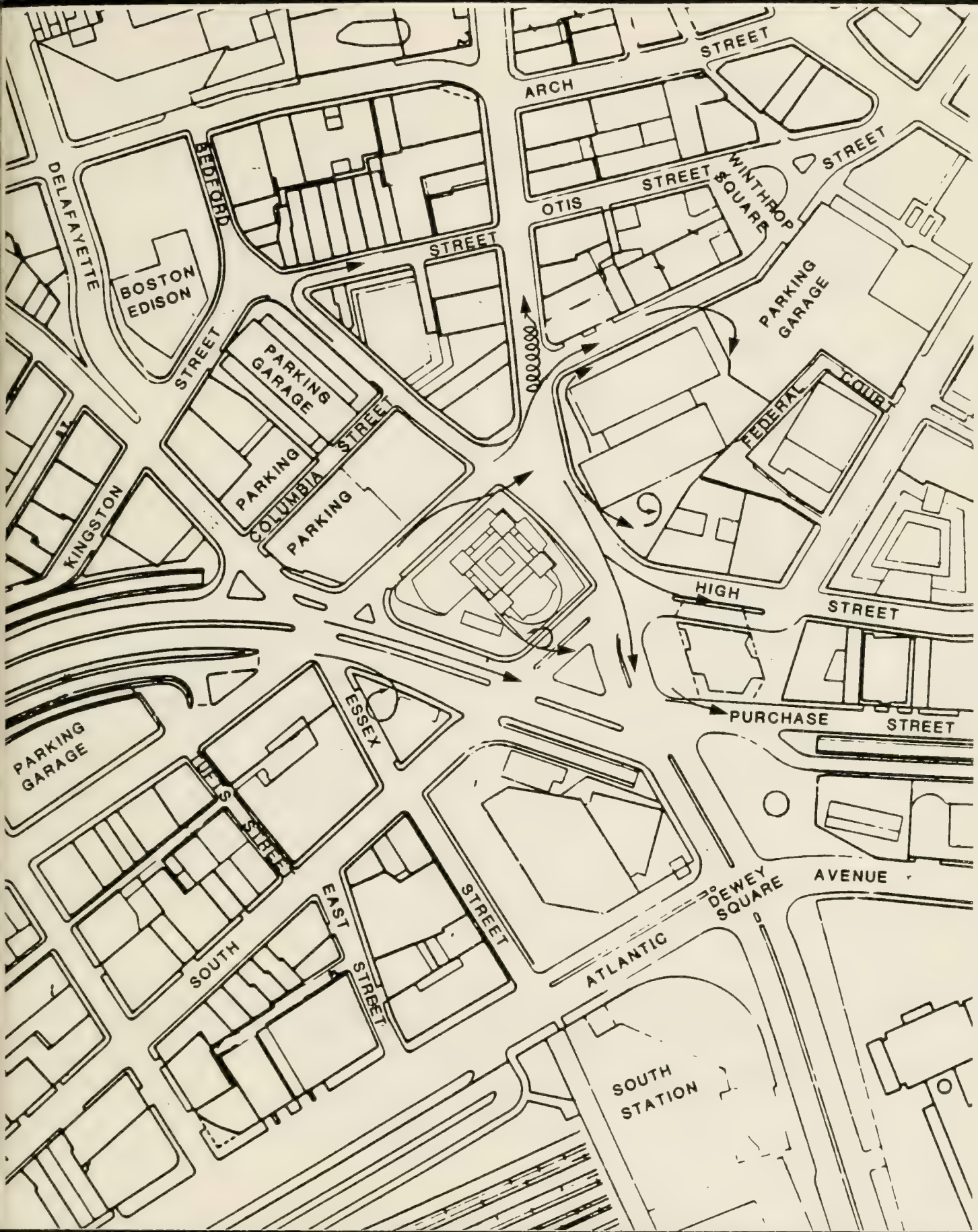


FIGURE 4.1-16 LOCAL WIND FLOW PATTERNS FOR SOUTHWEST WINDS

4.1.4.4 Conclusions

The results of the qualitative wind tunnel testing are summarized as follows:

1) Wind flow patterns in the 125 Summer Street project area are primarily influenced by 100 Summer Street. To a lesser extent, the One Financial Center and 99 Summer Street buildings influence wind patterns around the project site.

2) High wind velocities were observed near the southwest corner of the 100 Summer Street building. These high speeds occurred when winds were from the north, east, south, and northwest.

3) Windy conditions along Summer Street between the 100 Summer Street and the proposed 125 Summer Street project were also apparent when winds were from the east, southeast, west, and northwest directions.

4) Effects of the proposed project on the wind flow patterns was primarily limited to pedestrian ways directly adjacent to the project site. Due to the proposed height increase at this site accelerated flow was observed at one or more corners for most wind directions.

5) The proposed 125 Summer Street project provided some sheltering along Summer Street when winds were from the south.

6) During east winds the proposed building appears to draw the air stream along the project's half of Summer Street into its wake instead of allowing it to flow toward the southwest corner of 100 Summer Street as was evident under the No-Build configuration. A similar effect occurs when winds are from the west. In this case the air stream along the project's half of Summer Street is drawn into its wake region instead of the 100 Summer Street plaza area.

4.1.4.5 Proposed Test Measurement Locations for the Quantitative Analysis

The major purpose of the flow visualization study was to select locations for placement of hot wire anemometers for subsequent quantitative wind tunnel testing. The resulting array of suggested measurement locations are presented in Figure 4.1-19. Nineteen locations were selected following review of videotapes of wind effects for each of the major wind directions. The BRA reviewed these points and requested an additional ten points for study. These points are labelled 1 through 29 and are the subject of the quantitative analysis discussed in the following section.

4.1.5. Quantitative Analysis

4.1.5.1 Introduction

The quantitative analysis involved making numerical estimates of wind levels at selected study locations surrounding the 125 Summer Street site. The numerical estimates are based upon wind tunnel tests in which hot wire anemometers were used to measure wind speeds at the 29 receptor locations depicted in Figure 4.1-19.

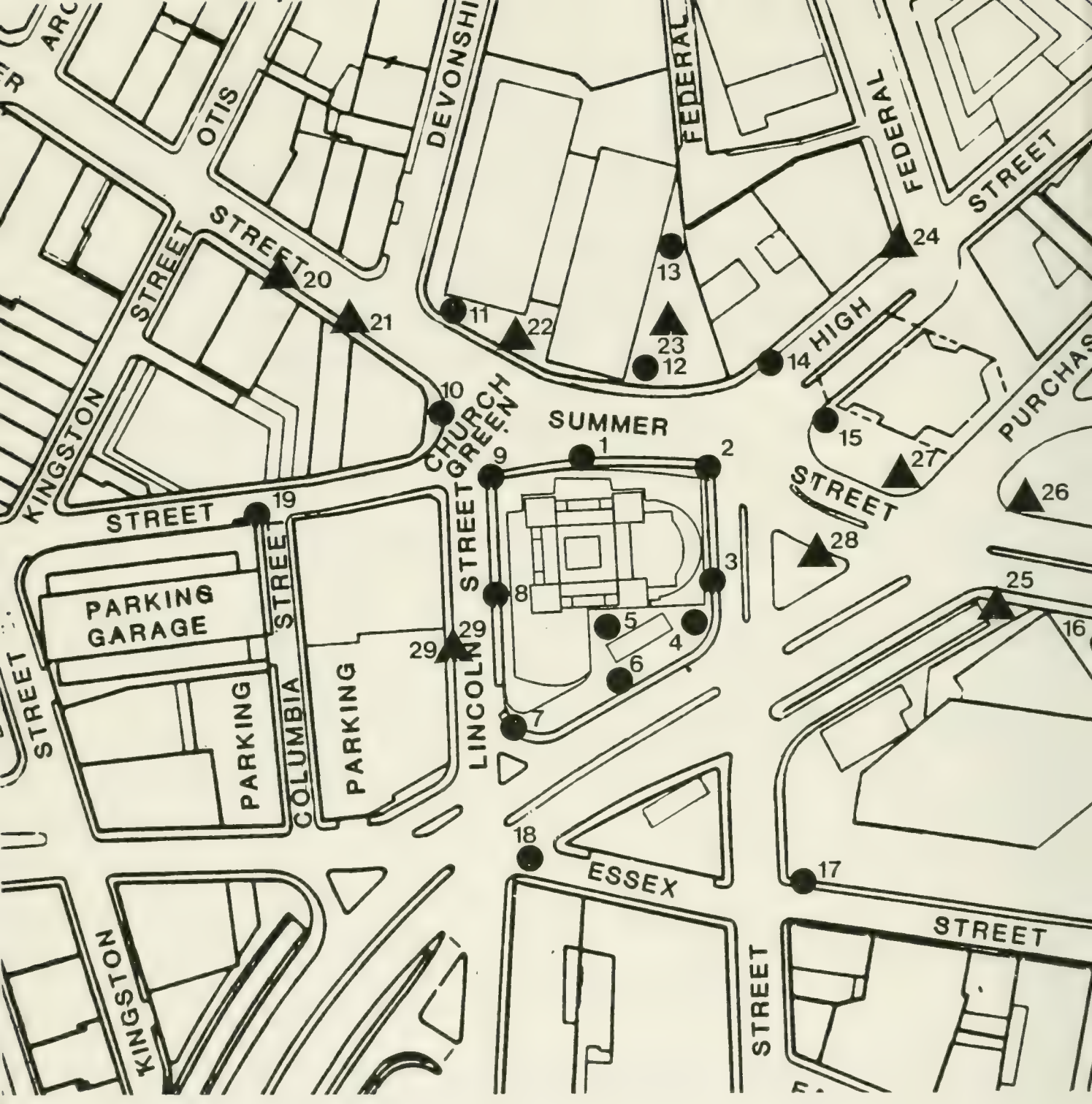


FIGURE 4.1-19 STUDY LOCATIONS FOR QUANTITATIVE ANALYSIS

The hot wire tests were run both for the project, as proposed, and for a "No-Build" condition in which the site was not developed. The results of the quantitative wind tunnel modeling have been used to compare these two conditions to each other, to the ambient wind environment in Boston, to reported wind levels at other sites in Boston and to the wind significance criteria introduced in Section 4.1.3 of this chapter. The subsequent subsections of the quantitative analysis describe:

4.1.5.2 Methods
4.1.5.3 Evaluation by the BRA Criteria
4.1.5.4 Evaluation by the Melbourne Criteria
4.1.5.5 Mitigating Measures
4.1.5.6 Conclusions

4.1.5.2 Methods

General

Pedestrian level velocity measurements were performed in the Boston University atmospheric boundary layer tunnel. A detailed description of the wind tunnel and City of Boston model utilized in the study is provided in the Qualitative Analysis (Section 4.1.4.2).

The model, which is mounted on a turntable, is rotated (1 Rev/600 Seconds) within the wind tunnel to simulate all wind directions while a hot wire anemometer is positioned at study locations to record wind velocity. Both data gathering and turntable motion were automatically driven by computer. The computer system was an IBM PC EX using a Metra Byte Dash 16 A-D board running in the DMA mode. Mean and root-mean-square (RMS) wind velocities were gathered at 3 degree intervals for each 360 degree rotation of the model, resulting in 120 data sets. Each

of these data sets consists of 1024 hot wire measurements sampled at 300 Hertz over a span of approximately 2 degrees. Non-dimensional wind velocities were calculated by dividing by the wind reference velocity at 30 inches in the tunnel which corresponds to 960 feet at full scale.

Mean and effective gust velocities (U_{Mean} +1.5 U_{RMS}) at each study location were calculated from wind tunnel results in conjunction with Boston climatological wind data as detailed below. Finally, results of the quantitative analysis were compared to the BRA wind design guidance level and Melbourne criteria described in Section 4.1.3.

Wind Exposure Profile

The atmospheric boundary layer for both the qualitative and quantitative analysis was approximated employing a power law profile of the mean velocity. The power law profile utilized was of the form:

$$\frac{\overline{U}(z)}{U_g} = \left(\frac{Z}{Z_g}\right)^{\alpha}$$

where $\overline{U}(z)$ is the mean velocity at the height z, U_g is the wind velocity at gradient height, and α is the power law exponent. The wind profile exponent, α, is a function of surface roughness and generally ranges from 0.14 for open terrain to 0.40 for large urban centers.

For the 125 Summer Street project a single wind profile exponent of 0.30 was used. This wind profile exponent, which corresponds to suburban/urban terrain, was selected consistent with other wind tunnel studies performed for projects well within the financial district which had a range from 0.23 to 0.30

Wind Data Base

National Weather Service anemometers at Logan International Airport provide a major source of local surface wind data. This surface data must be translated to gradient height by use of assumed velocity profiles. Such profiles may vary with wind direction for a location like Logan Airport due to differing upwind surface conditions. Fortunately, in addition to the Logan surface measurements, "winds aloft" data is available obtained by weather balloon releases. This data set provides information on winds up to the top of the atmospheric boundary layer. The records are of observations of wind speeds 500m above ground. This data set was used to develop a statistical model of the winds above the atmospheric boundary layer.

The pedestrian wind environment is judged on the basis of relatively frequently-occurring events rather than on the extreme winds which must be used in the design of the building. Therefore, a different approach to analysis of the meterological data base is appropriate. Wind records maintained by the National Oceanic and Atmospheric Administration are compiled in a wind summary covering some period (usually 10 years) and consist of tables of observations summarized monthly and annually. The summaries are divided into data for 16 discrete wind sectors where each sector is 22.5° wide, and is centered on a named direction. For example, north winds denoted "N" are winds originating from compass north $\pm$11.25°. Other sectors include northeast (NE), east-northeast (ENE), east (E), etc. Within each sector, several velocity ranges are defined, with the number or percentage of observations of hourly mean wind speed listed in each range. By approximately fitting a probabilistic model to the data for each wind sector, estimates can be made of the probability that the wind will exceed some speed for each sector. The total probability of exceeding the given wind speed can be computed by combining the likelihood that the wind will originate from each sector with the probability that, if it does, a given wind speed will be exceeded.

The proabilistic model selected to fit the Boston wind data is a Weibull distribution having the following mathematical form:

$$P_i(>U) = \exp[-(\frac{U}{C_i})^{K_i}]$$

where $P_i(U)$ denotes the probability of exceeding velocity U at the i^{th} wind direction sector and K_i and C_i are constants (being a function of wind direction). The constant C_i primarily reflects the mean speed observed while K_i relates primarily to the rate of decay of probability with higher velocities (U).

The tabulated climatological wind data were fitted to this statistical model for each wind direction sector and month. Monthly data were then collated to define appropriate seasonal and annual wind statistics. This was accomplished by forming histograms for each sector, and performing a least-squares analysis to approximate one "K_i, C_i" pair for each of the four seasons and annual time interval.

The statistical fit of the wind data is performed by summing over all sectors and representing the total probability of exceeding a velocity, U, by the expression:

$$P\ (>U) = \sum_{L=1}^{16} P(\theta_i)\ \ \exp\left[(\frac{U}{C_i})^{K_i}\right]$$

The parameter $P(\theta_i)$ represents the fraction of time that the wind blows from the i^{th} wind direction sector and is derived from tabluated Boston wind data.

This model includes long term variations by utilizing climatological data for each of the 16 wind direction sectors. The data base consists of observations of wind speeds above the maximum altitude to which the atmospheric boundary layer would penetrate. In experiments, wind speeds were referenced to an elevation of 960 ft. For Boston the top of the boundary layer (gradient height) upstream of the site model is taken to be

approximately 1200 ft. To convert the statistical model of wind speeds at the gradient height to wind speeds at 960 ft., the power law relation was used. The resulting estimate of the ratio of mean velocity at 960 ft. reference height to mean velocity of 500m above the airport is 0.935.

The statistical model representing Boston's wind data was further refined to be consistent with the data gathering procedure of recording mean and RMS wind levels at three degree increments. Newly derived values of K_i, C_i, and Po_2 were developed to fit Boston wind data to 120 individual azimuths (i.e., every three degrees). The refined statistical model was therefore redefined utilizing the following expression.

$$P\ (>U) = \sum_{i=1}^{120} P(\theta_i)\ \exp\left[\left(\frac{U}{C_i}\right)^{K_i}\right]$$

Thus, wind tunnel velocity measurements taken at three degree intervals could be merged with a complete set of Boston wind data of similar form. Figures 4.1-2 through 4.1-6 show polar plots of probable-azimuths-of-occurrence and probability-of-exceedance of the mean velocity at the 960 ft. reference height at the project site.

Data Reduction

Tests performed in the Boston University wind tunnel involved monitoring wind speed at the gradient height in conjunction with recording pedestrian level wind velocities at all study locations presented in Figure 4.1.19. Measurements of the gradient height wind velocity were made using the tunnels pitot static probe, while pedestrian level wind velocities were determined with a hot-wire anemometer. The tunnel pitot probe was cross calibrated with laboratory instrumentation and the hot-wire anemometer was then calibrated against the calibrated tunnel pitot tube. The gradient height velocity was maintained at a constant speed of 9.84 meters per second.

Wind velocity data recorded during the wind tunnel tests were reduced to provide a normalized mean and effective gust velocity (egv) as a function of wind direction at each study location for both the No-Build and Build alternatives. These normalized parameters are defined as follows:

i) normalized mean velocity $\quad U_n = \frac{\overline{U}}{U_g}$

where $\overline{U}$ = mean velocity measured at pedestrian level

U_g = gradient height velocity

ii) normalized egv $\quad egv = \frac{\overline{U} + 1.5\, U_{RMS}}{U_g}$

where: U_{RMS} is the root-mean-square of the time varying velocity component (u(t)) such that the wind velocity is given by $U(t) = U + u'(t)$ or:

$$U_{RMS} = \frac{1}{T}\left[\int_0^T (u'(t))^2\, dt\right]^{1/2}$$

The mean velocity therefore is a measure of the average wind velocity component while the egv provides an indication of the degree of gustiness at a study location.

To enable comparison to the comfort criteria presented in Section 4.1.3, the wind velocity data were merged with the previously described long-term statistical model of actual Boston wind data. The wind tunnel results were combined with both the Boston seasonal and annual data to provide cumulative probability distributions of the full scale mean and effective gust velocities at each study location. Finally from the

cumulative probability distribution, mean and effective gust velocities exceeded 1, 5, 10, 20 and 50% of the time were determined on a seasonal and annual basis. The 5% - 20% occurrence frequencies correspond to criteria for more casual use of the pedestrian spaces, for which lower wind speeds are appropriate (see Copley Wind Study and EIR).

Quantitative Analysis

The complete data are contained in Appendix A. A summary of the data is given in Table 4.1-2, 4.1-3, 4.1-4 and 4.1-5. Tables 4.1-2 and 4.1-3 give the mean wind speeds exceeded 1, 5, and 20% of the time for the No-Build and Build cases. Tables 4.1-4 and 4.1-5 give the gust wind speeds exceeded 1.5 and 20% of the time for the No-Build and Build cases.

In Table 4.1-6, we organize the data according to gust levels for the No-Build cases. If, in the No-Build case, a location did not exceed 31.5 mph then, the addition of the building never increases the gust winds above the informal BRA criteria of 31.5 mph. There are several locations in which the existing wind exceeds the BRA criteria. In all but one, the addition of the building does not significantly change these winds. However, at the windiest location, the building decreases the winds by 3.3 mph. Table 4.1-6 shows that there are several locations at which gust winds increased by more than 2 mph (points 3, 5, 6, 7, 14, 28, 29). At all these locations, the 1% gust velocities are less than 31.5 mph.

In Table 4.1-7, we present the mean wind speeds exceeded 1% of the time. The data are organized as in Table 4.1.6. In general, those areas which have high gust level will have high mean winds. Mean winds increase by more than 2 mph at four stations (7, 8, 14, 29). In all of these locations, the winds with 125 Summer Street never exceed 19 mph more than 1% of the time, i.e., the 1% mean speeds are all less than 19 mph. If we refer to Figure 4.1-20, we see that the Melbourne criteria indicate all these stations are acceptable for walking.

TABLE 4.1-2

125 SUMMER STREET NO-BUILD MEAN WIND SPEEDS (MPH)

EXCEEDED BY FREQUENCY OF OCCURRENCE

Location	1%	5%	20%
1	20.0	14.4	9.7
2	16.4	11.8	7.6
3	14.5	10.4	7.2
4	14.4	9.3	6.0
5	10.8	7.5	4.2
6	13.8	10.2	6.8
7	11.7	8.5	5.6
8	11.1	8.2	5.2
9	18.5	13.8	9.2
10	21.2	16.1	10.6
11	25.2	19.3	13.1
12	23.3	16.5	10.1
13	12.9	9.3	5.9
14	12.9	8.9	5.5
15	14.8	11.2	7.8
16	20.5	12.8	7.5
17	24.5	16.6	8.5
18	15.2	11.0	7.3
19	15.4	10.6	6.0
20	16.3	11.5	7.3
21	18.4	12.6	7.3
22	9.8	7.4	5.0
23	19.4	12.9	6.9
24	19.3	14.1	9.0
25	28.5	20.8	13.1
26	28.0	20.9	13.7
27	29.1	21.3	13.4
28	17.2	12.8	8.8
29	11.1	8.1	5.1

TABLE 4.1-3

125 SUMMER STREET BUILD MEAN WIND SPEEDS (MPH)

EXCEEDED IN TERMS OF FREQUENCY OF OCCURRENCE

Location	1%	5%	20%
1	18.2	13.7	9.5
2	16.7	12.4	8.1
3	15.7	11.0	7.3
4	14.9	9.3	5.5
5	9.6	6.6	3.5
6	15.7	12.0	8.2
7	18.7	14.1	9.2
8	13.5	10.1	6.6
9	19.5	13.8	8.9
10	19.3	14.3	9.2
11	26.2	19.8	13.3
12	24.0	16.5	9.6
13	10.9	7.8	5.0
14	15.7	11.3	6.9
15	16.4	12.3	8.4
16	20.3	12.7	7.0
17	24.1	16.5	7.9
18	15.4	11.0	7.1
19	13.8	9.4	5.4
20	12.8	9.6	6.5
21	17.5	11.9	6.9
22	11.1	8.5	5.7
23	17.4	11.6	6.3
24	17.0	21.3	7.0
25	28.1	20.1	11.8
26	27.2	20.3	13.0
27	26.3	19.5	12.6
28	18.8	13.7	9.2
29	14.2	10.7	7.7

TABLE 4.1-4

125 SUMMER STREET NO-BUILD GUST WIND SPEEDS (MPH)

EXCEEDED IN TERMS OF FREQUENCY OF OCCURRENCE

Location	1%	5%	20%
1	27.6	20.1	13.7
2	26.5	19.9	13.4
3	22.1	15.9	11.0
4	22.8	15.3	10.1
5	18.2	12.9	7.7
6	21.0	15.7	10.9
7	18.5	13.9	9.7
8	19.6	14.7	9.6
9	30.7	22.8	15.4
10	32.4	25.0	17.1
11	32.6	25.2	17.5
12	33.4	24.1	15.3
13	19.8	15.0	10.0
14	20.0	14.6	9.8
15	24.1	18.2	12.8
16	30.6	21.0	13.4
17	34.3	23.8	13.8
18	24.6	18.4	12.5
19	22.7	16.2	9.9
20	24.8	18.3	12.3
21	26.4	18.8	12.1
22	18.9	14.3	12.1
23	30.1	20.7	11.8
24	29.2	21.9	14.5
25	37.3	28.1	18.7
26	37.8	28.2	18.8
27	38.1	28.1	18.3
28	27.4	20.3	14.1
29	18.3	13.8	9.3

TABLE 4.1-5

125 SUMMER STREET BUILD GUST WIND SPEEDS (MPH)

EXCEEDED IN TERMS OF FREQUENCY OF OCCURRENCE

Location	1%	5%	20%
1	25.7	19.3	13.4
2	26.1	19.9	13.6
3	25.0	18.2	12.3
4	22.0	15.4	9.9
5	16.0	11.2	6.4
6	24.4	18.8	13.0
7	26.3	19.9	13.4
8	20.6	15.7	10.8
9	31.2	22.8	15.2
10	31.2	23.8	16.1
11	34.0	26.1	17.9
12	33.5	24.0	14.9
13	17.4	13.0	8.8
14	25.6	18.5	11.7
15	25.9	19.6	13.5
16	30.5	20.7	12.7
17	34.2	23.6	12.5
18	24.0	17.8	12.2
19	21.3	15.0	9.4
20	21.8	16.7	11.6
21	26.2	18.6	11.9
22	20.6	15.6	10.5
23	29.3	20.3	11.4
24	25.9	18.5	12.1
25	36.9	27.2	17.0
26	37.2	27.9	18.3
27	35.4	26.7	18.0
28	30.5	22.7	15.4
29	21.8	16.6	11.0

TABLE 4.1-6

125 SUMMER STREET GUST WIND SPEEDS EXCEEDED 1% OF THE TIME

ORDERED IN TERMS OF PRESENT IMPORTANCE

Location	No Build (MPH)	Build (MPH)	Difference (MPH)
27	38.1	35.4	-3.3
26	37.8	37.2	-0.6
25	37.3	36.9	-0.4
17	34.3	34.2	-0.1
12	33.4	33.5	0.1
11	32.6	34.0	1.8
10	32.4	31.2	-1.2
9	30.7	31.2	0.5
16	30.6	30.5	-0.1
23	30.1	29.3	-0.8
24	29.2	25.9	-3.3
1	27.6	25.7	-1.9
28	27.4	30.5	3.1
2	26.5	26.1	-0.4
21	26.4	26.2	-0.2
20	24.8	21.8	-3.0
18	24.6	24.0	-0.6
15	24.1	25.9	1.8
4	22.8	22.0	-0.8
19	22.7	21.3	-1.4
3	22.1	25.0	2.9
6	21.0	24.4	3.3
14	20.0	25.6	5.6
13	19.8	17.4	-2.4
8	19.6	20.6	1.0
22	18.9	20.6	1.7
7	18.5	26.3	7.8
29	18.3	21.8	3.5
5	18.2	16.0	2.2

Overall Reductions 16
Increases 13

Because we have called out locations 7 and 28 as points of concern, we have plotted them in terms of the Melbourne criteria in Figure 4.1-20. We find that, for each of these points, the addition of the new building places these locations within the limit of the acceptable range for walking. According to these criteria, these locations would be acceptable.

4.1.5.3 Evaluation by the BRA Criteria

As present, with no new construction, seven locations exceed the informal BRA criteria of windiness. In five of these cases the new building reduces these winds, in two of the cases the new building increases the winds. Also, the project causes a marginal exceedence at one additional location such that under the build configuration eight locations exceed the 31 mph criterion. Because of measurement error we must decide whether these changes are significant. Only changes greater than 2 mph are considered significant. From this point of view, the only significant change is that the new building reduces the wind at the most dangerous location. The windiest locations are as follows:

Point 27 - The south corner of the Fiduciary Trust Building. At this location the winds are comparatively high for all but a north wind. The effect of the new building is to reduce the intensity when the wind carries from the west or east.

Point 26 - The north corner of Summer Street opposite Financial Center. This location is close to location 27 and again we observe comparatively high winds from all directions except north. Shielding due to the new building is reduced because the location is further away from the new building. Nevertheless, a reduction in the 1% gust level is observed.

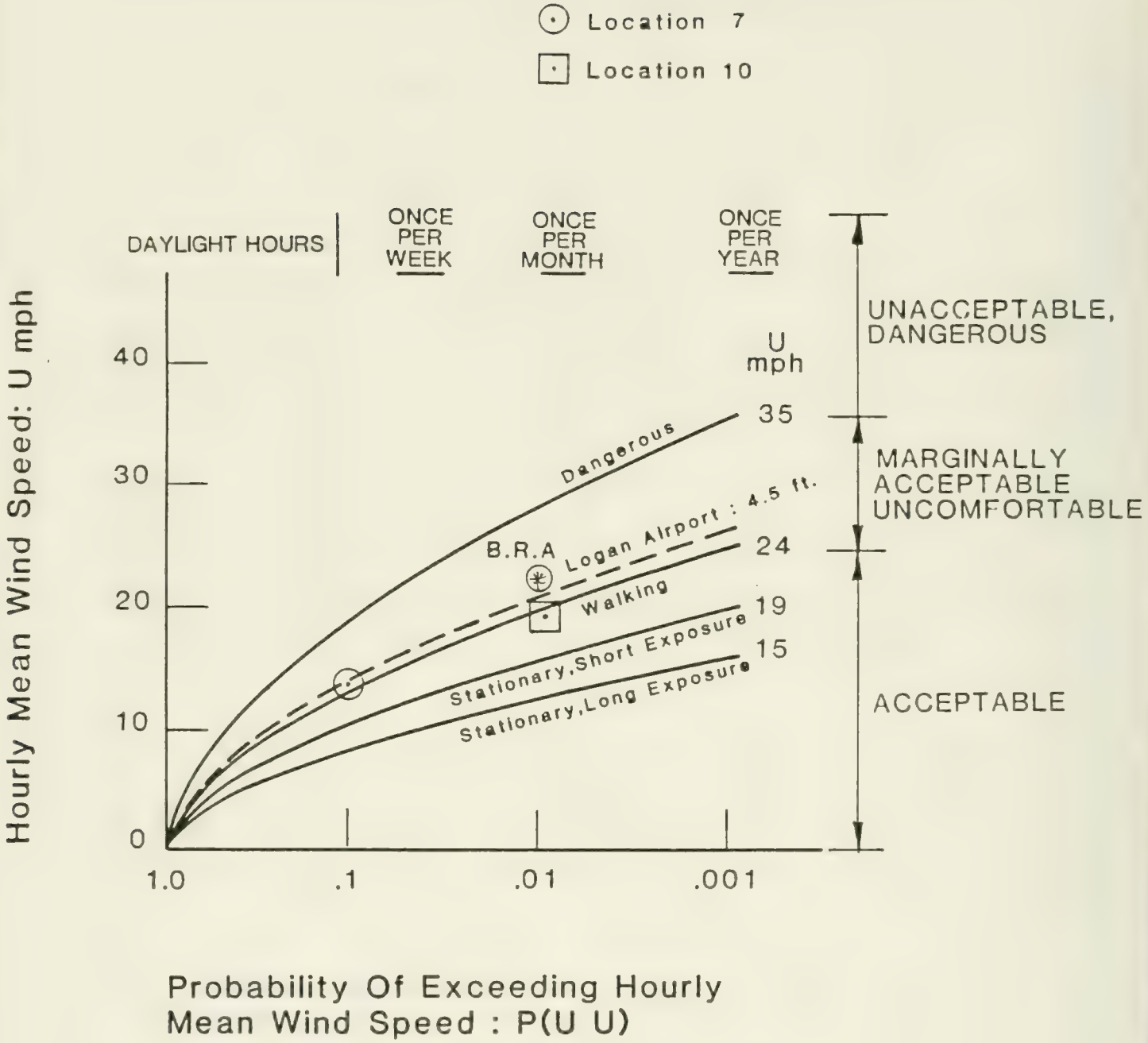


FIGURE 4.1-20 LOCATIONS 7 AND 28 COMPARED TO MELBOURNE'S CRITERIA FOR AVERAGE HOURLY PEDESTRIAN WINDS COMPARED WITH OTHER REFERENCES

TABLE 4.1-7

125 SUMMER STREET MEAN WIND SPEEDS EXCEEDED 1% OF THE TIME

ORDERED IN TERMS OF PRESENT IMPORTANCE

Location	No-Build (MPH)	Build (MPH)	Difference (MPH)
27	29.1	26.3	-2.7
25	28.5	28.1	-0.4
26	28.0	27.2	-0.8
11	25.2	26.2	1.0
17	24.5	24.1	-0.4
12	23.3	24.0	0.7
10	21.2	19.3	-1.9
16	20.5	20.3	0.2
1	20.0	18.2	-1.8
23	19.4	17.4	-2.0
24	19.3	17.0	-2.3
9	18.5	19.5	1.0
21	18.4	17.5	-0.9
28	17.2	18.8	1.6
2	16.4	16.7	0.3
20	16.3	12.8	-3.5
19	15.4	13.8	-1.6
18	15.2	15.4	0.2
15	14.8	16.4	1.6
3	14.5	15.7	1.2
4	14.4	14.9	0.5
6	13.8	15.7	1.9
14	12.9	15.7	2.8
13	12.9	10.9	-2.0
7	11.7	18.7	7.0
8	11.1	13.5	2.4
29	11.1	14.2	3.1
5	10.8	9.6	-1.2
22	9.8	11.1	1.3

Overall Reductions 12
Increases 17

Point 25 - The north corner of Financial Center. This location is close to locations 26 and 27 and again we observe comparatively high winds from all directions except north. Once again the new building blocks the west and eastwind and this causes a reduction in the 1% gust level.

Point 17 - The west corner of Financial Center. On the velocity diagrams we observe very high winds from the south. The new building does not significantly change these winds.

Point 12 - The southern corner of 100 Summer Street. Here the highest winds occur at all directions except for a north wind. Wind tunnel results indicated a gust velocity increase of 0.1 mph which is well within the resolution of wind tunnel modeling.

Point 11 - The southeast corner of 100 Summer Street. Here the highest observed winds are from the south and north. This effect is probably due to channeling of the flow along Devonshire Street. The new building has a small effect on the south level due to a wind that causes a 1.8 mph increase in the 1% gust level.

Point 10 - The apex of the intersection of Summer and West Bedford Streets. Here the highest levels are due to the north wind. The new building tends to lower the level due to the north wind and reduces the 1% gust levels by 1.2 mph. With the new building, this location exceeds the 1% annual gust level deemed unacceptable by the BRA by only 0.2 mph.

Point 9 - At study location 9, (the northwest corner of the project site), the proposed building resulted in an increase of the 1% gust velocity of 30.7 mph under the existing case to 31.2 for the build configuration. This

0.5 mph increase is well within the 1 mph accuracy limits of wind tunnel testing.

4.1.5.4 Evaluation by the Melbourne Criteria

The locations that have the highest gust winds also have the highest mean winds. Thus we can discuss the same points as before. Because we use the Melbourne criteria we can now arrange the points into three broad categories: dangerous (1% annual mean wind greater than 27.5 mph), marginally acceptable (1% annual mean wind less than 27.5 mph but greater than 19 mph), and acceptable (1% annual mean wind less than 19 mph).

Point 27 - The south corner of the Fiduciary Trust Building. At present this location is dangerous. The new building reduces the winds so that the location is marginally acceptable. According to the Melbourne Criteria although the winds are decreased at this location with the building, they are still unacceptable according to the BRA criterion (mean wind speeds not exceeding 23 mph).

Point 26 - The north corner of Summer Street opposite the Financial Center. At present this location is dangerous. The new building reduces the wind level but the location is still marginally acceptable.

Point 25 - The north corner of Financial Center. At present, this location is dangerous. The new building reduces the wind from 28.5 mph to 28.1 mph.

Point 17 - The west corner of Financial Center. This location is marginally acceptable. The new building reduces the mean wind level, but the location is still only marginally acceptable.

Point 12 - The south corner of 100 Summer Street. At present this location is marginally acceptable. The new building increases the level by a small (0.7 mph) amount and the location remains marginally acceptable.

Point 11 - The southeast corner of 100 Summer Street. At present this location is marginally acceptable. The new building increases the level by a small (1.0 mph) amount, hence the location remains marginally acceptable.

Point 10 - The apex of the intersection of Summer and West Bedford Streets. At present this location is marginally acceptable. The new building reduces the level so that the location is almost (19.3 mph) acceptable.

The most pronounced effect of the new building was at location 7, the southwest corner of the proposed building. We note that though the increase in mean wind speed is 7.0 mph, the location is still well within the acceptable range (18.7 mph) according to the Melbourne criteria.

According to the Melbourne criteria, there are four other locations that are now only marginally acceptable. These are location 16, 23, 24, and 1. With the new building there are now only two additional locations that are marginally acceptable: 9 and 16.

4.1.5.5 Mitigating Measures

Normally mitigating measures are considered for new buildings in which the project design contributes to either a) exceedances of the BRA wind significance criterion or b) significant increases in ambient winds regardless of the absolute value of winds. These conditions are largely absent with the 125 Summer Street project. As indicated previously in Table 4.1.7 only 4 test locations were subjected to increases of more than 2.0 mph in mean velocities exceeded 1% of the time.

These increases, however, are at locations with the lowest measured mean wind speeds. Even with the increase all these points are acceptable by the Melbourne criteria. At the higher end of mean wind speeds only at locations 11 and 12 were small increases noted.

Under the build configuration the pedestrian level wind analysis demonstrated eight study locations with measured gust velocities above the BRA criterion of 31 mph (see Table 4.1-6). Comparison of the no-build and build data, however, demonstrate the project mitigated one percent gust velocities at five (10, 17, 25, 26 and 27) of these eight locations. The projects podium design likely aids in minimizing project wind related impacts directly adjacent to the project site. At the three remaining study locations (9, 11 and 12) where exceedences of the BRA criterion occurred under the build configuration, gust velocities increases of less than 2 mph were measured. Further, velocity increases of less than or equal to 0.5 mph were noted at locations 9 and 12. This wind increase is well below the 1 mph resolution of the wind tunnel testing itself and are thus expected to be insignificant. At study location 11 the project increased the existing exceedence of 32.6 mph to 34.0 mph (+1.8 mph).

Generally wind related mitigation measures short of building redesign include foliage plantings and canopies. The buildings current podium design, however, already provides wind related benefits. Canopies are generally beneficial at building entrances to protect pedestrians from downward deflected winds on the windward side of a building while foliage plantings serve as wind breaks by absorbing wind energy.

Study location 11, situated at the southwest corner of 100 Summer Street, was noted to have a 1.8 mph gust velocity increase with the proposed project. Results presented above demonstrate that winds from the north channeled along Devonshire Street and also winds from the east and south cause worst case conditions. Canopies at two or three stories (along 100 Summer Street) above street level may provide some benefits, however,

at a corner location such as this non-deciduous tree plantings will likely provide the best results by serving as a wind break. It appears that Devonshire Street provides little room for such plantings, however, some space may be available at the Summer Street side of this corner. It is along Summer Street, near this intersection, that worst case conditions have generally been observed in the past and where mitigating measures appear most necessary. Mitigating measures associated with alleviating wind condition at both locations 11 and 12 would require negotiations with owners of 100 Summer Street.

4.1.5.6 Conclusions

Mean annual winds as high as 29 mph were measured at locations near the 125 Summer Street site. Eight of the 29 measurement locations were deemed to be hot spots at which the winds exceeded the BRA gust velocity criteria of 31 mph one percent of the time. Seven of these eight locations also exceed the BRA threshold under the No-Build condition. At five of these locations, the wind is projected to be reduced with the 125 Summer Street building in place. Wind speeds are projected to be increased at two locations (11, 12) and would be increased from marginally acceptable to marginally unacceptable (Melbourne criteria) at station 9, the northwest corner of the project site.

At the three stations at which the wind velocity is increased, two stations were projected to increase by an amount smaller than the resolution of the test (1 mph). Only station 11 was projected to increase by an amount greater than the measurement resolution. A discussion of mitigating measures at this site is included in 4.1.5.5.

Figures 4.1-21 and 4.1-22 summarize the data for mean wind and gust winds exceeded one percent of the time.

The windiness is due both to high ambient winds in Boston and to the complex urban geometry that exists in the Financial District. The First National Bank appears to be a dominating presence with respect to winds. Effects of other high rise

buildings, such as 100 Summer Street and the Shawmut Bank, are apparent as well. Likewise, the dense urban development in the Financial District provides many opportunities for channeling of winds in the city streets.

In general, the addition of the new building at 125 Summer Street has little net effect on local winds. There is virtually no significant change in effective gust velocity at 18 of the 29 test locations. Four of the remaining sites experience decreased wind effective gustiness. The other seven points experience high winds with or without the new building. For most locations, conditions are neither appreciably better nor worse with 125 Summer Street in place. One notable exception is that the new building reduced the winds at the worst location so that it went from dangerous to marginally acceptable (based on Melbournes Criteria - see discussion in Section 4.1.3). In short, the project has little net effect on local wind environment.

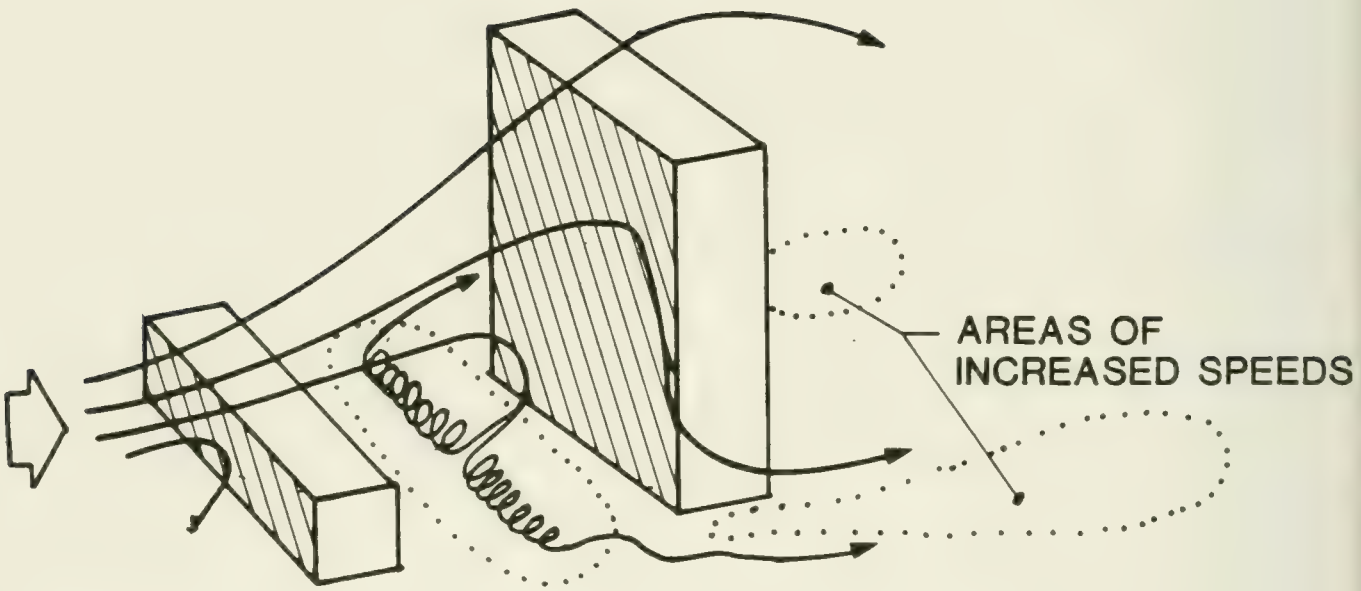


FIGURE 4.1-1 TYPICAL FLOW PATTERNS BETWEEN HIGH AND LOW RISE BUILDINGS

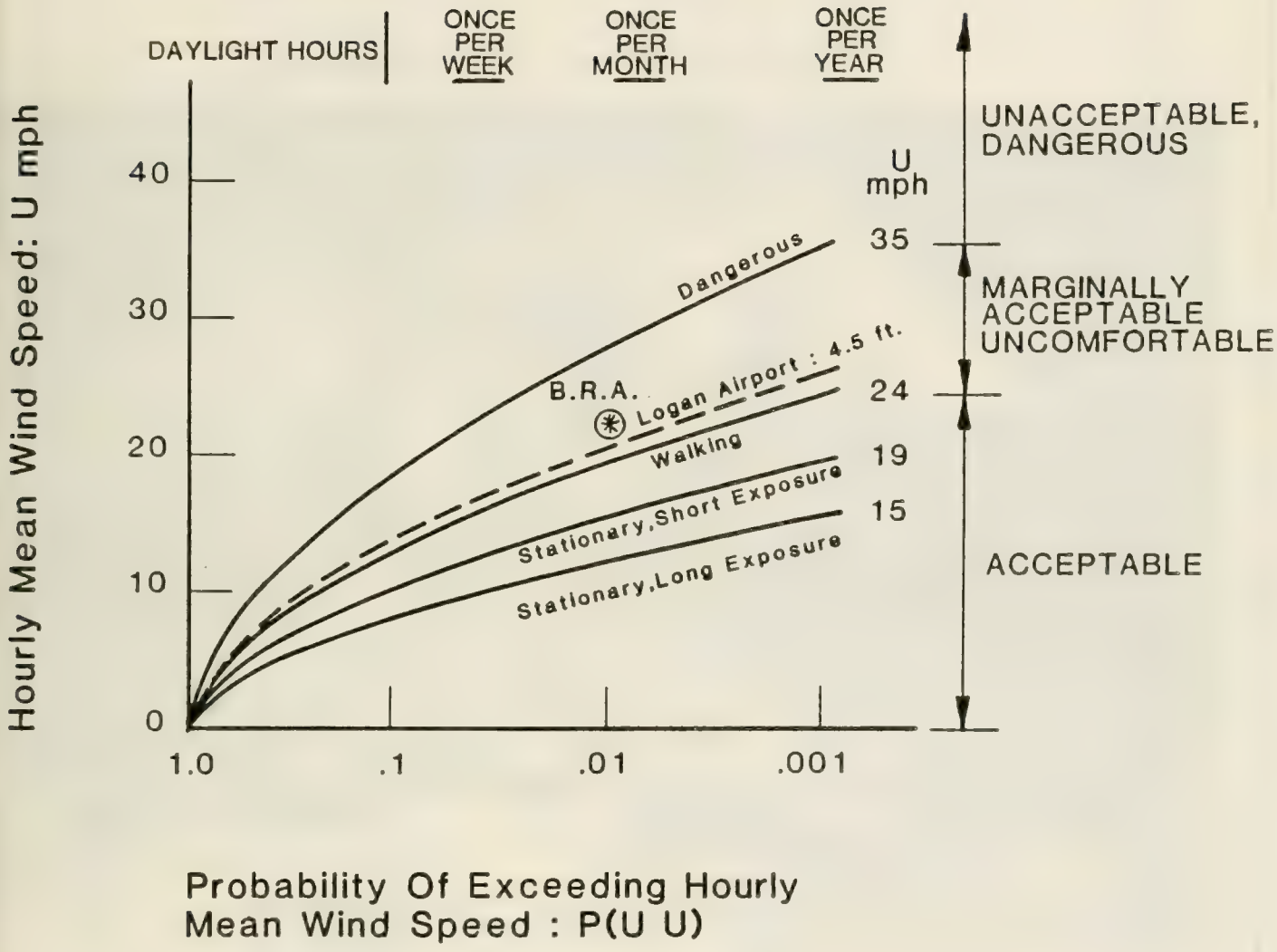


FIGURE 4.1.7 MELBOURNE'S CRITERIA FOR AVERAGE HOURLY PEDESTRIAN WINDS COMPARED WITH OTHER REFERENCES

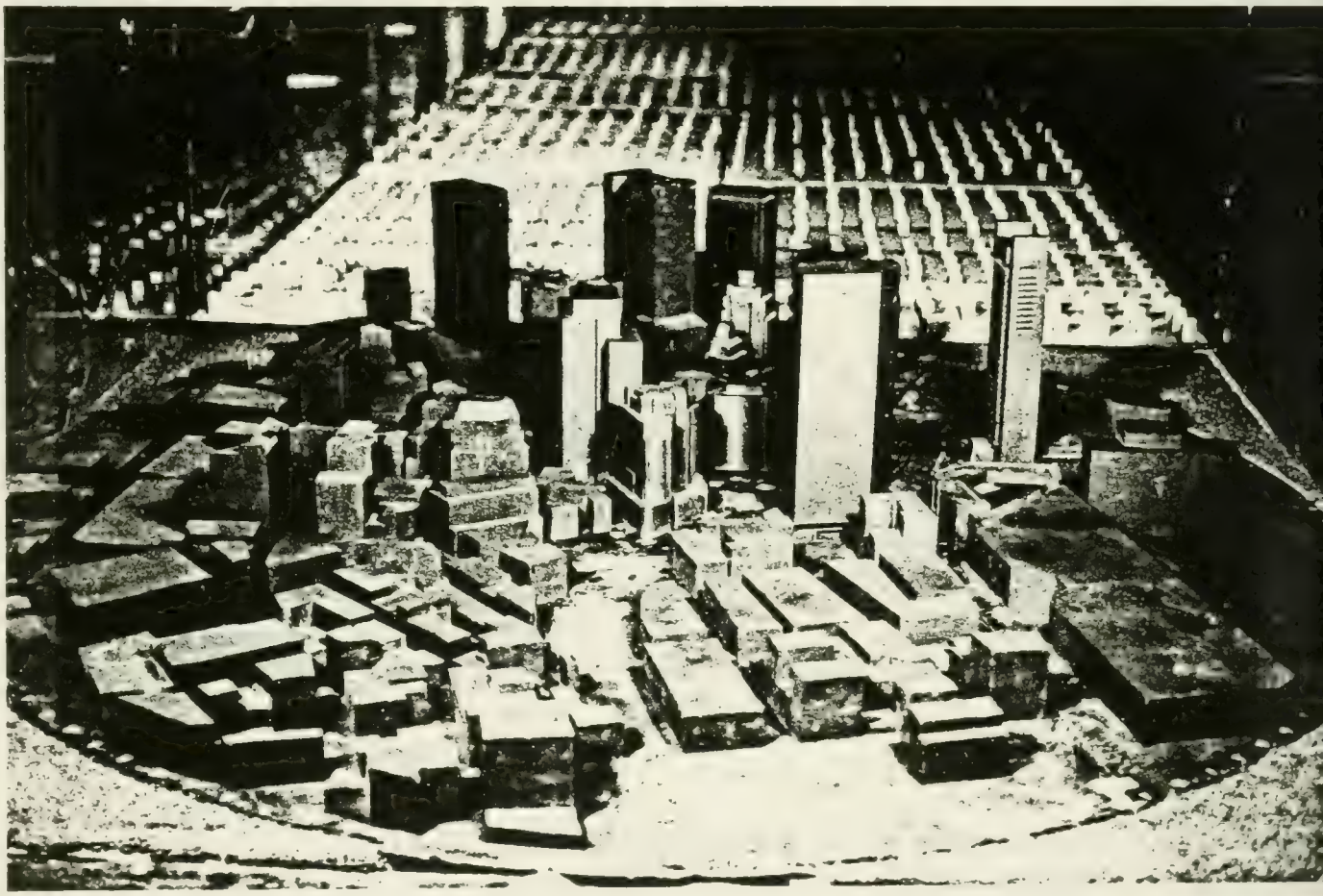


FIGURE 4.1.8 PHOTOGRAPH OF WIND TUNNEL MODEL FOR 125 SUMMER STREET TESTS

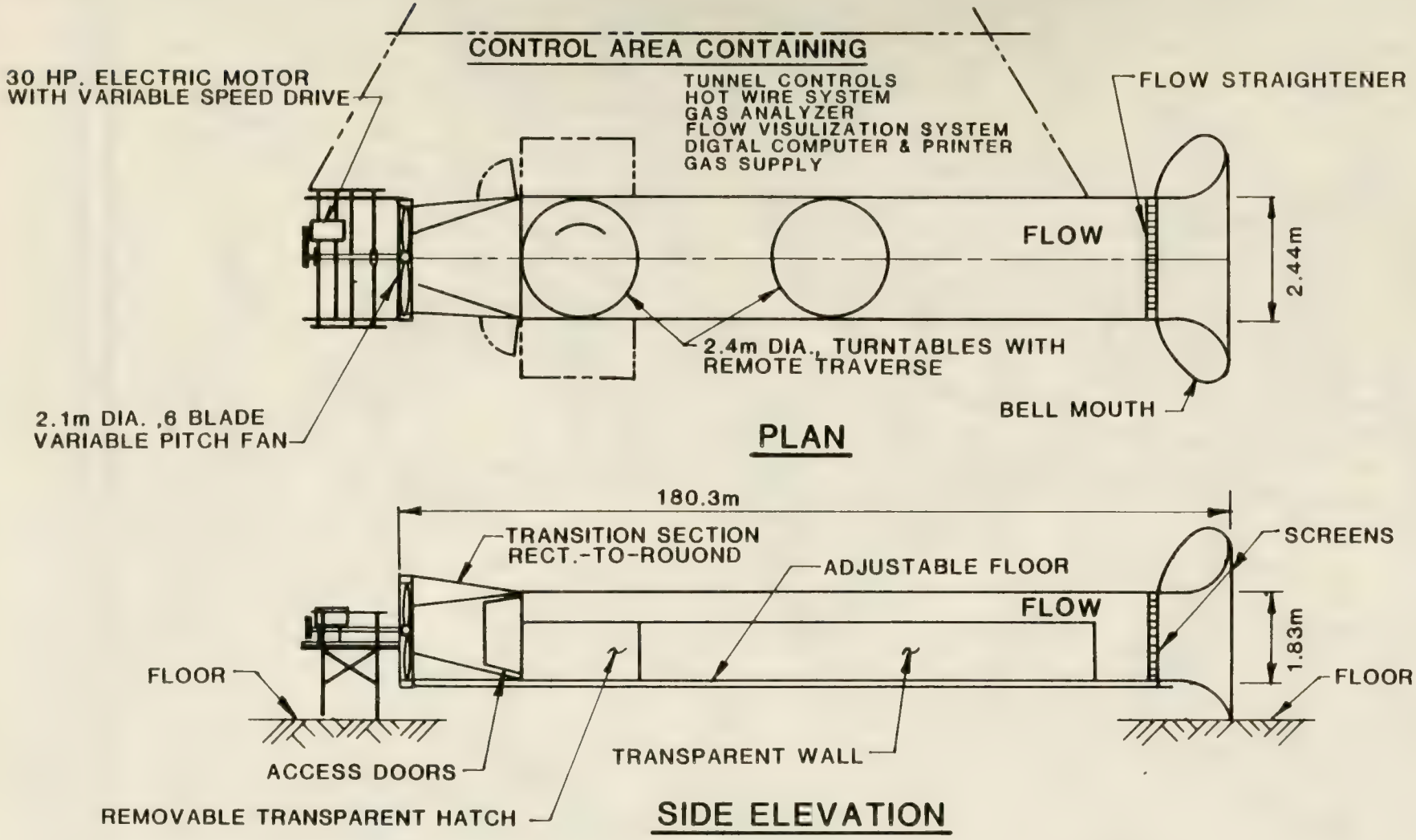


FIGURE 4.1.9 BOSTON UNIVERSITY BOUNDARY LAYER WIND TUNNEL

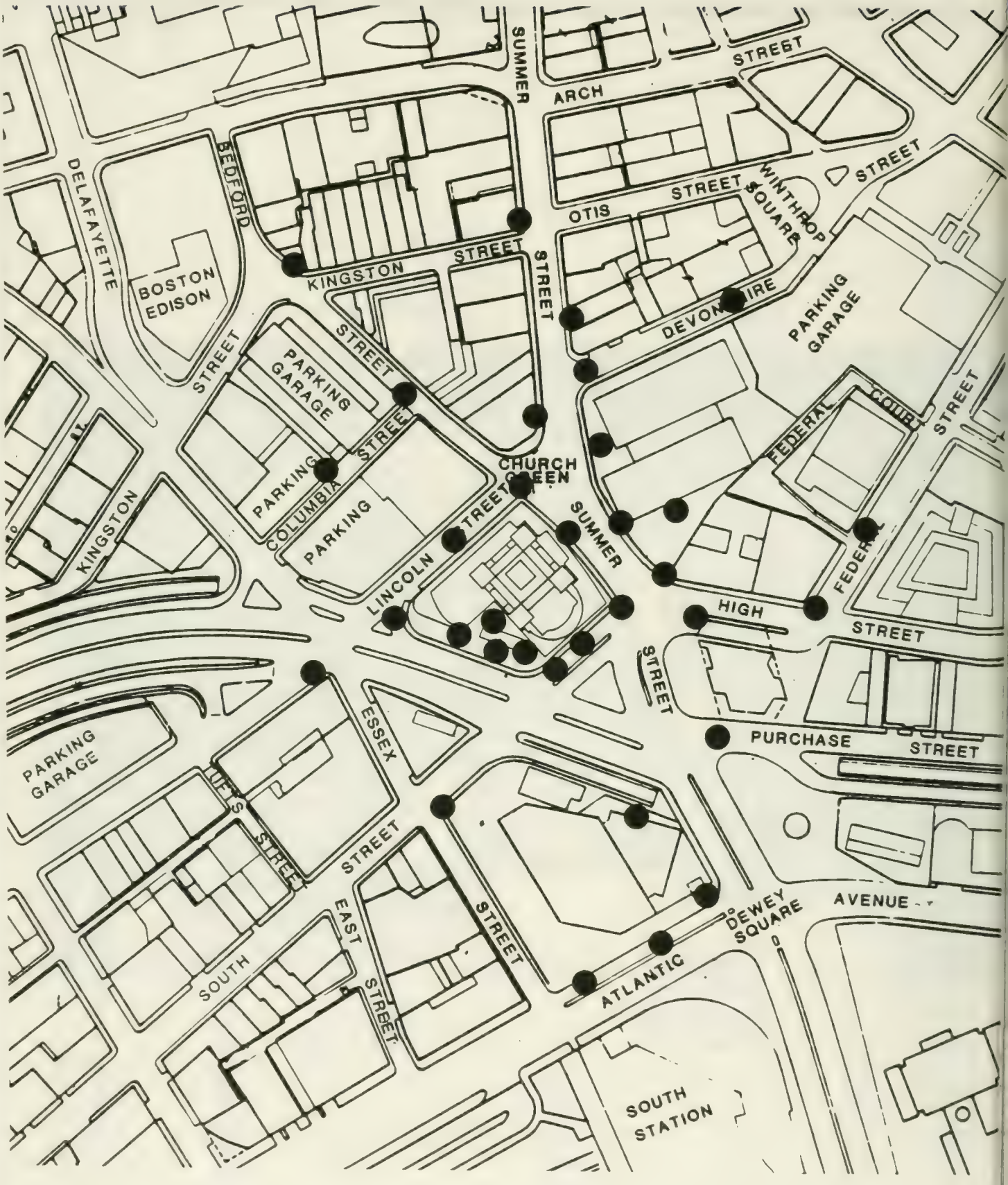


FIGURE 4.1-10 SMOKE TEST STUDY SCHEME

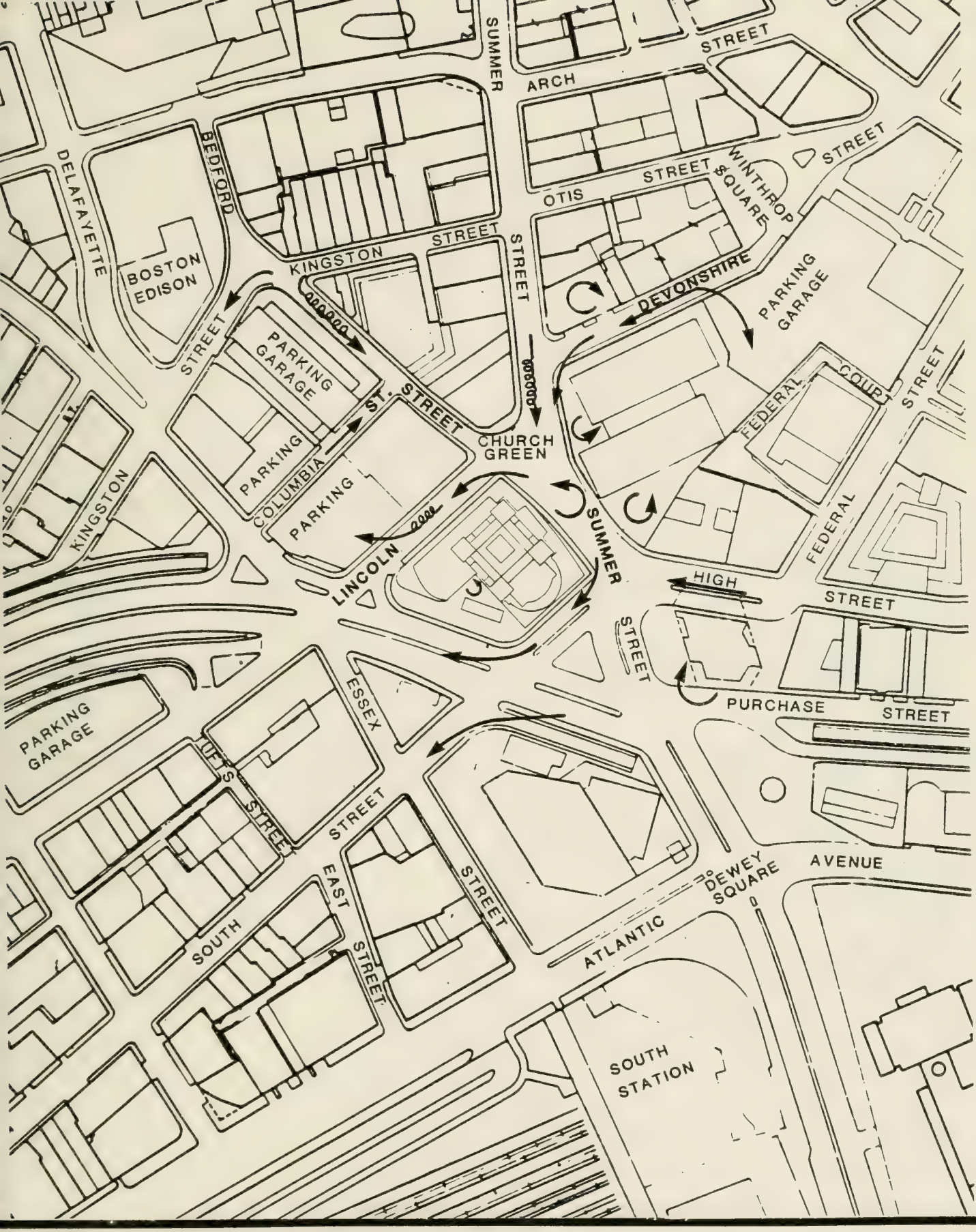


FIGURE 4.1-11 LOCAL WIND FLOW PATTERNS FOR NORTH WINDS

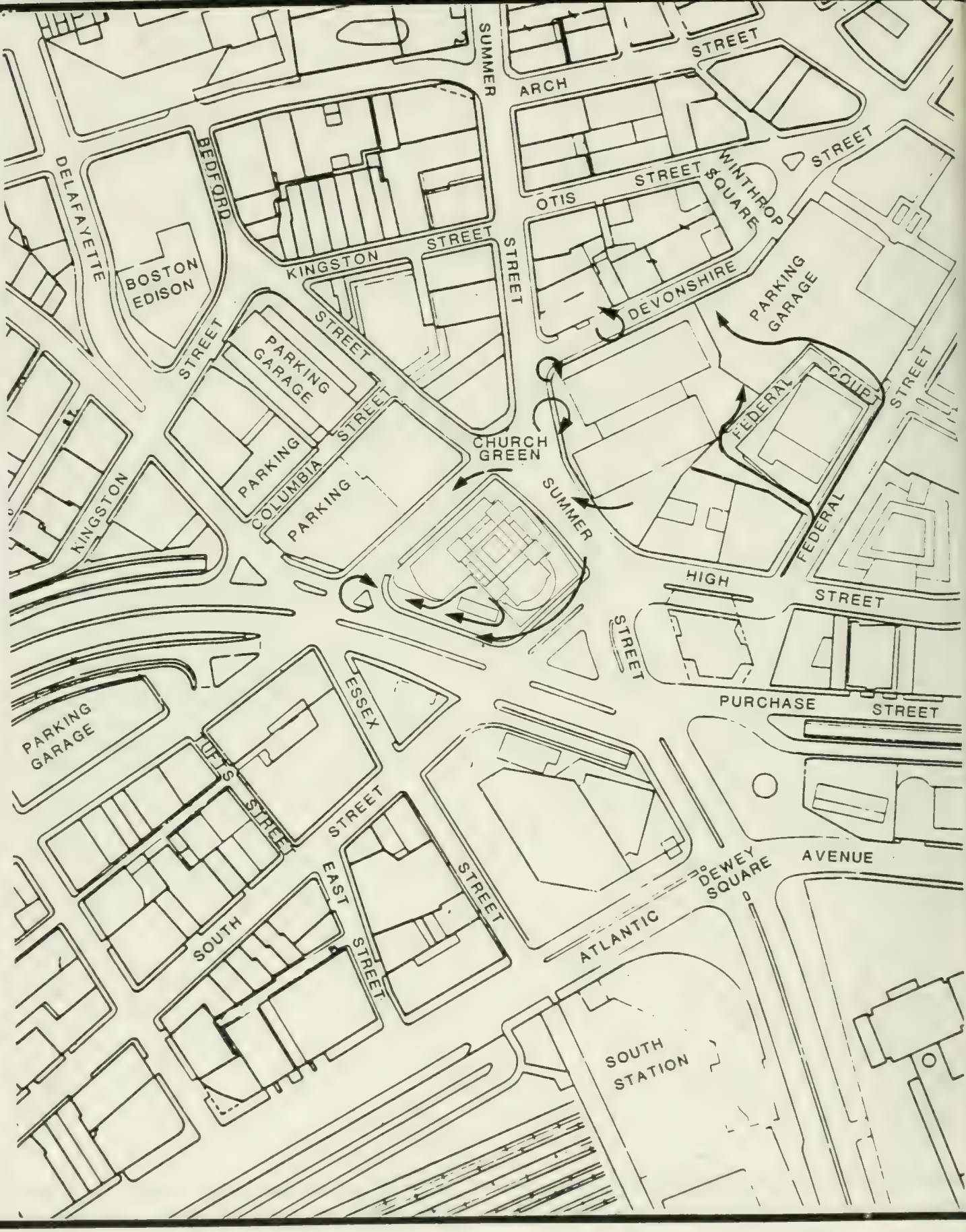


FIGURE 4.1-12 LOCAL WIND FLOW PATTERNS FOR NORTHEAST WINDS

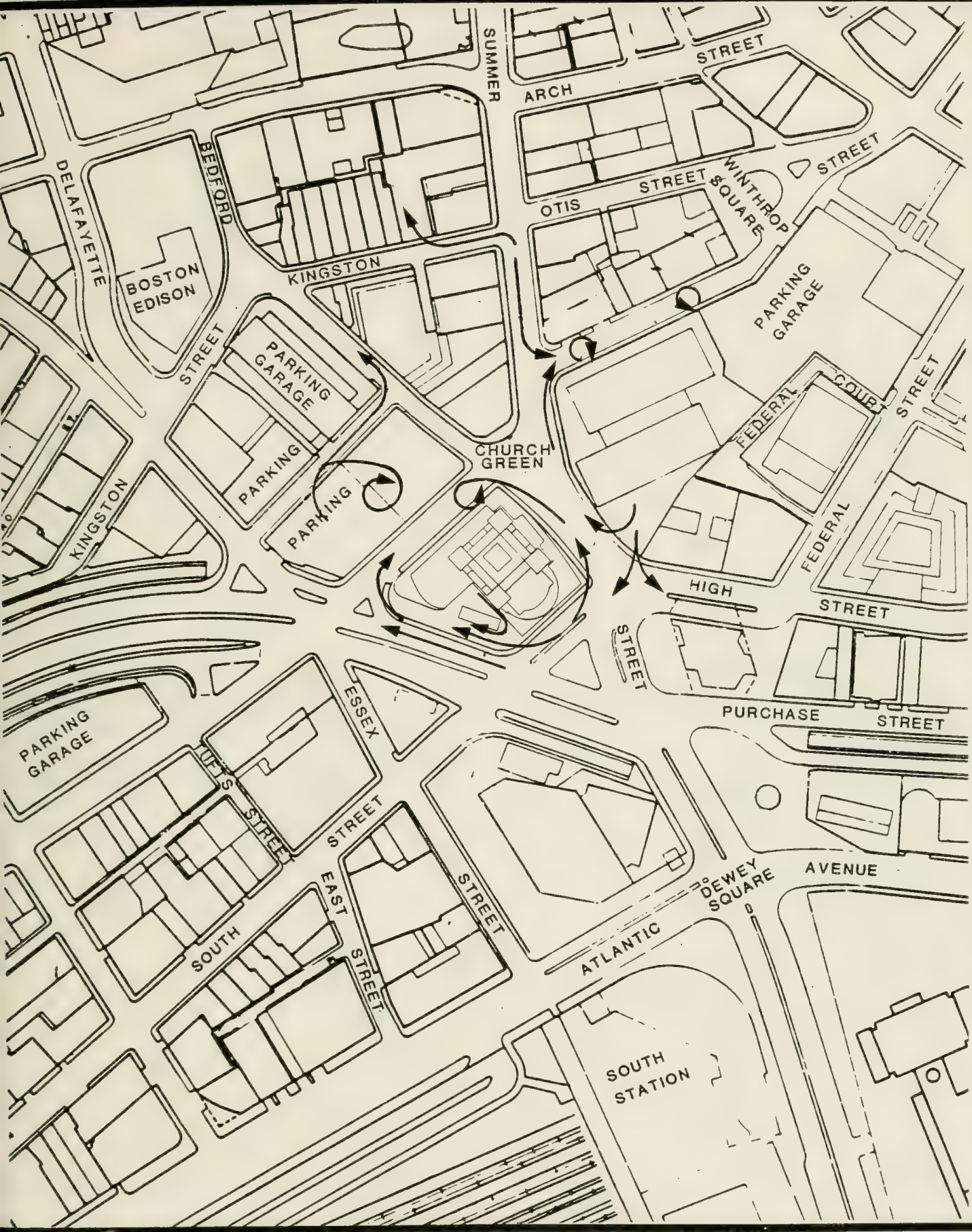


FIGURE 4.1-13 LOCAL WIND FLOW PATTERNS FOR EAST WINDS

FIGURE 4.1-14 LOCAL WIND FLOW PATTERNS FOR SOUTHEAST WINDS

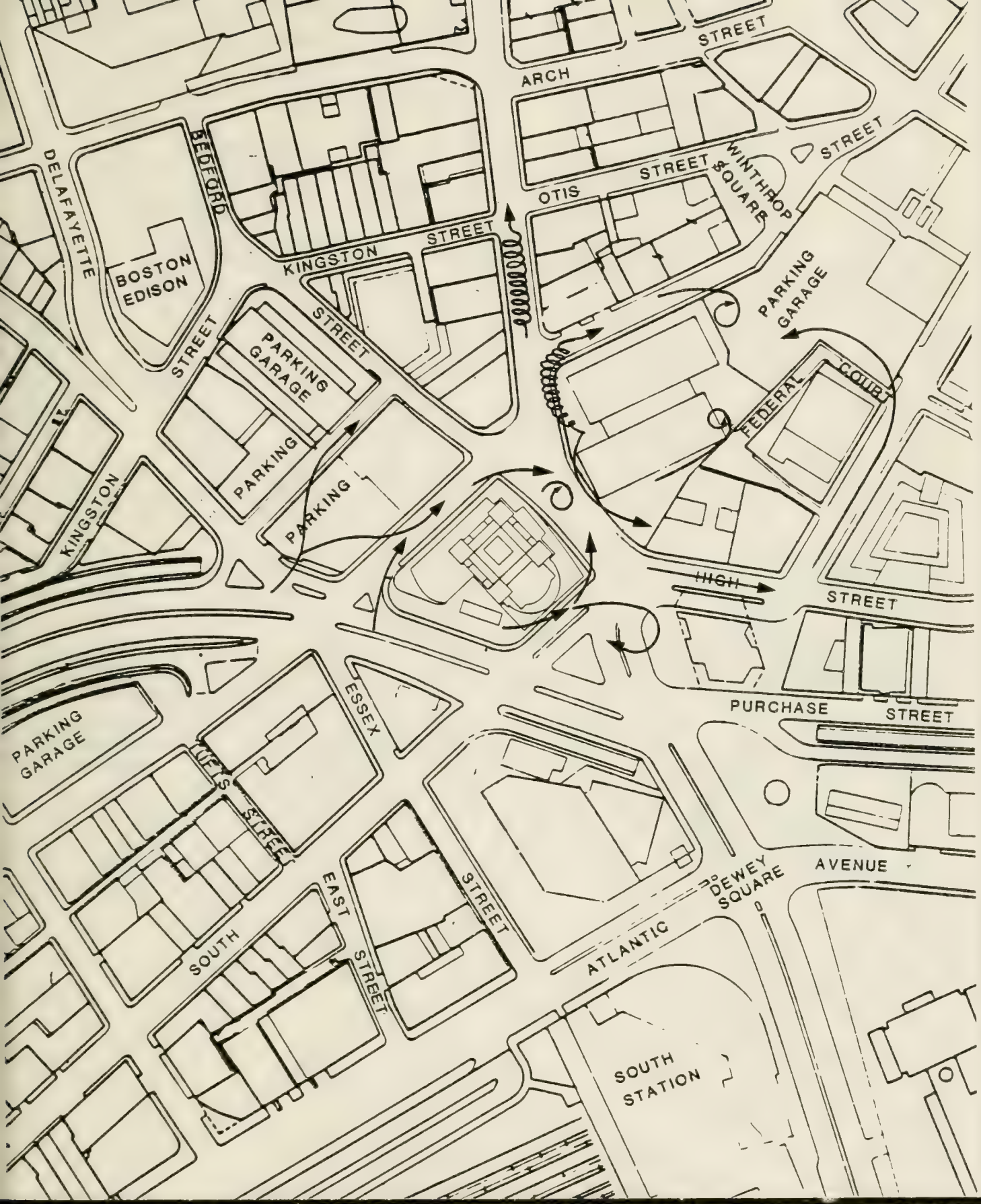


FIGURE 4.1-15 LOCAL WIND FLOW PATTERNS FOR SOUTH WINDS

HMM Associates

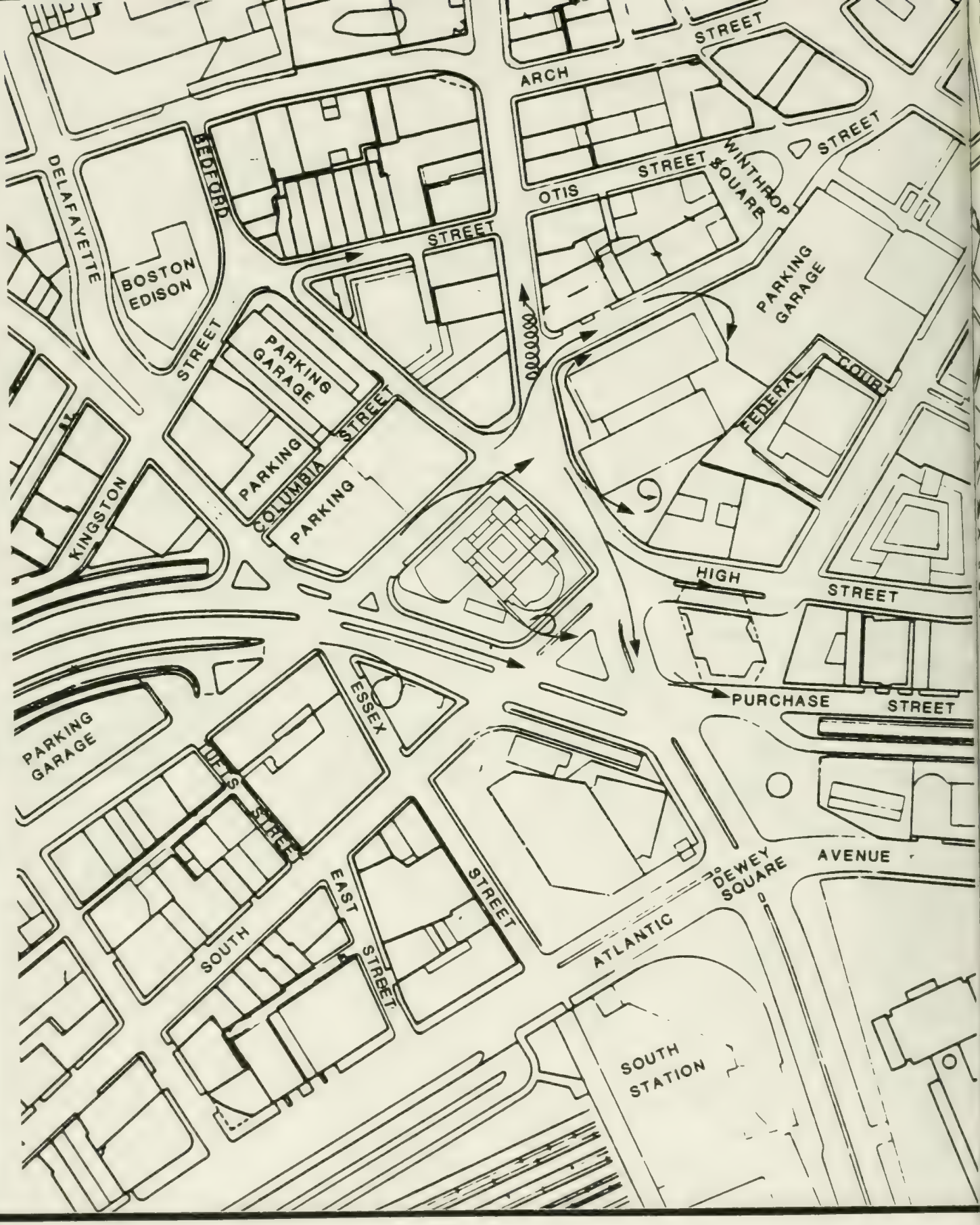


FIGURE 4.1-16 LOCAL WIND FLOW PATTERNS FOR SOUTHWEST WINDS

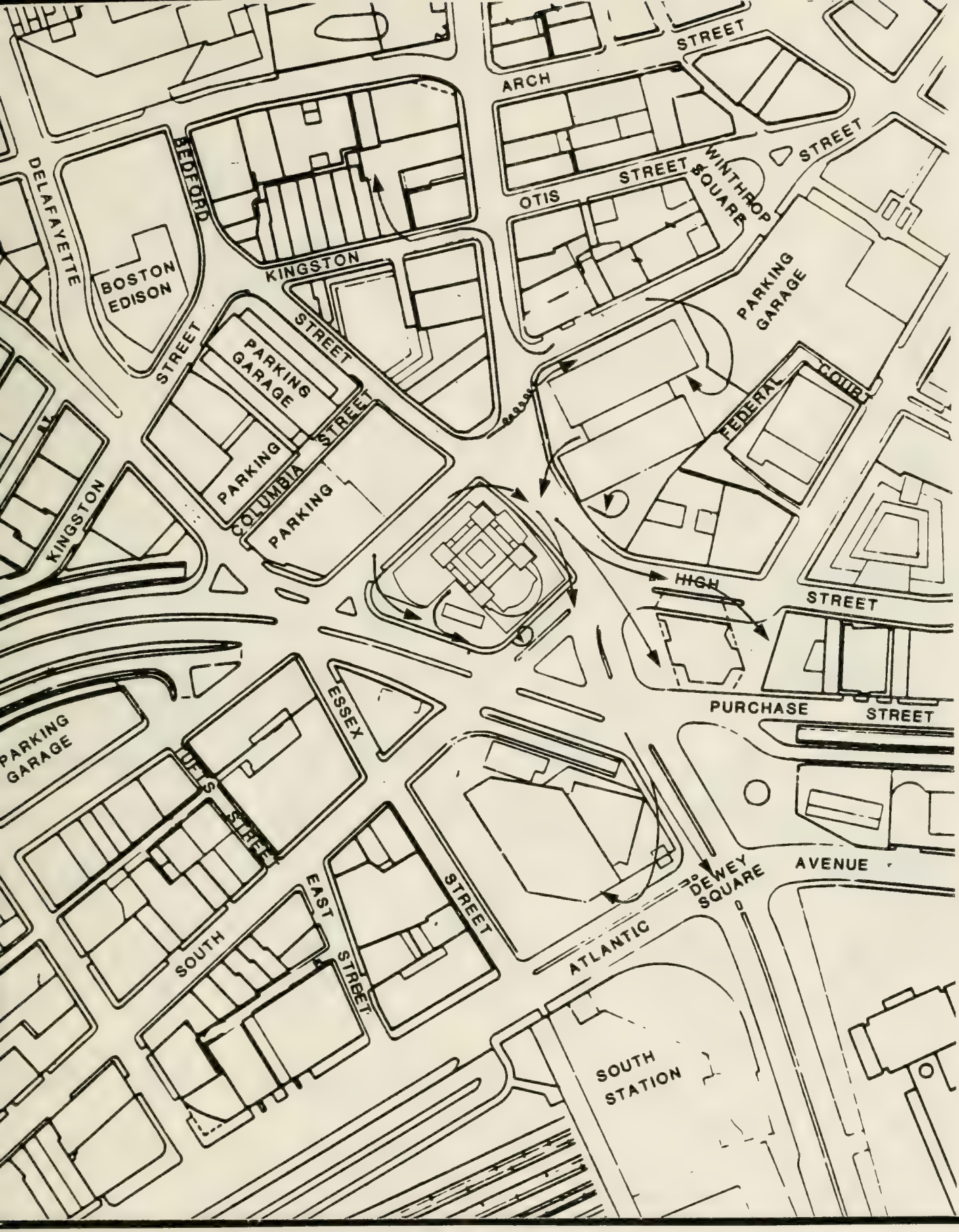


FIGURE 4.1-17 LOCAL WIND FLOW PATTERNS FOR WEST WINDS

HM Associates

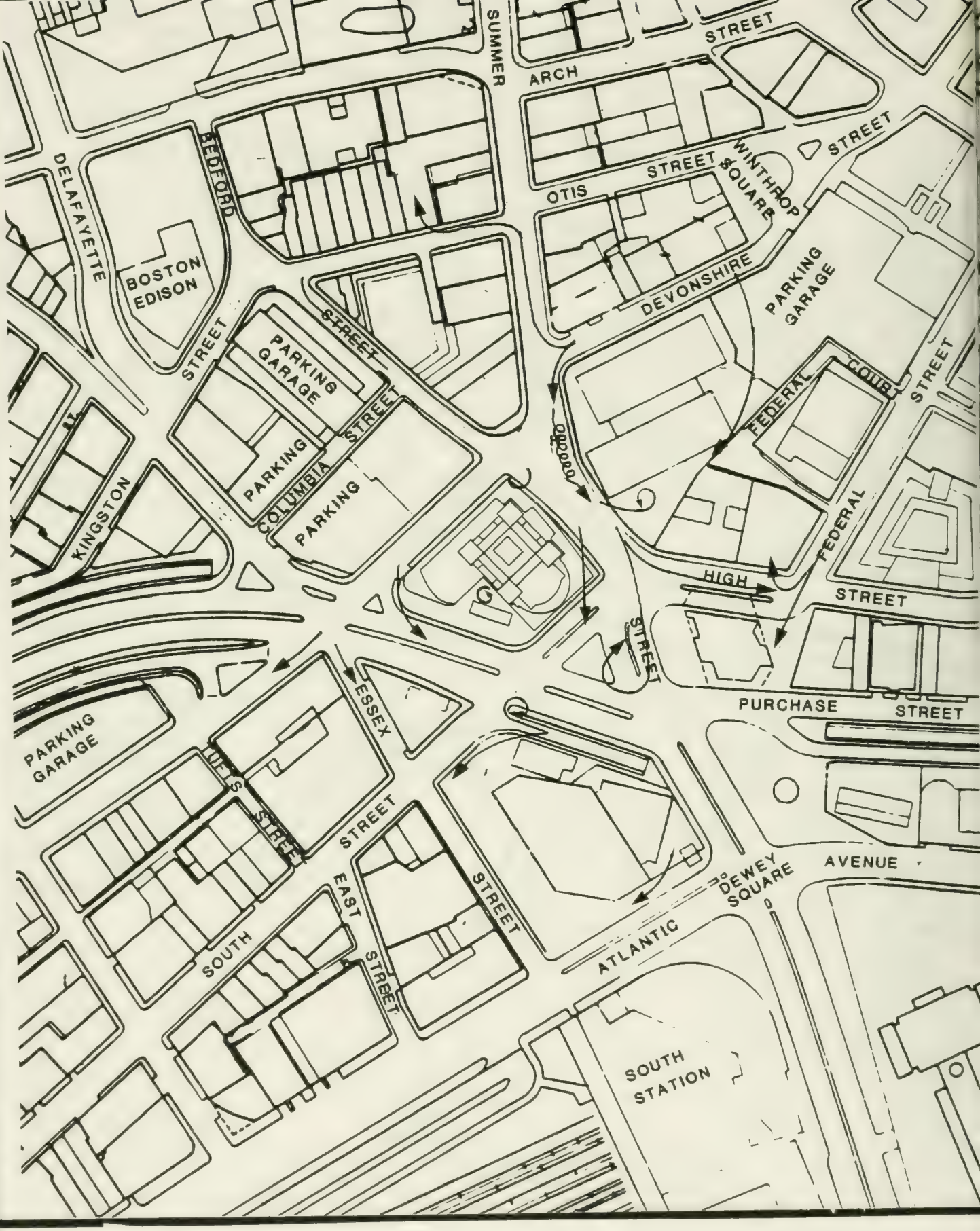


FIGURE 4.1-18 LOCAL WIND FLOW PATTERNS FOR NORTHWEST WINDS

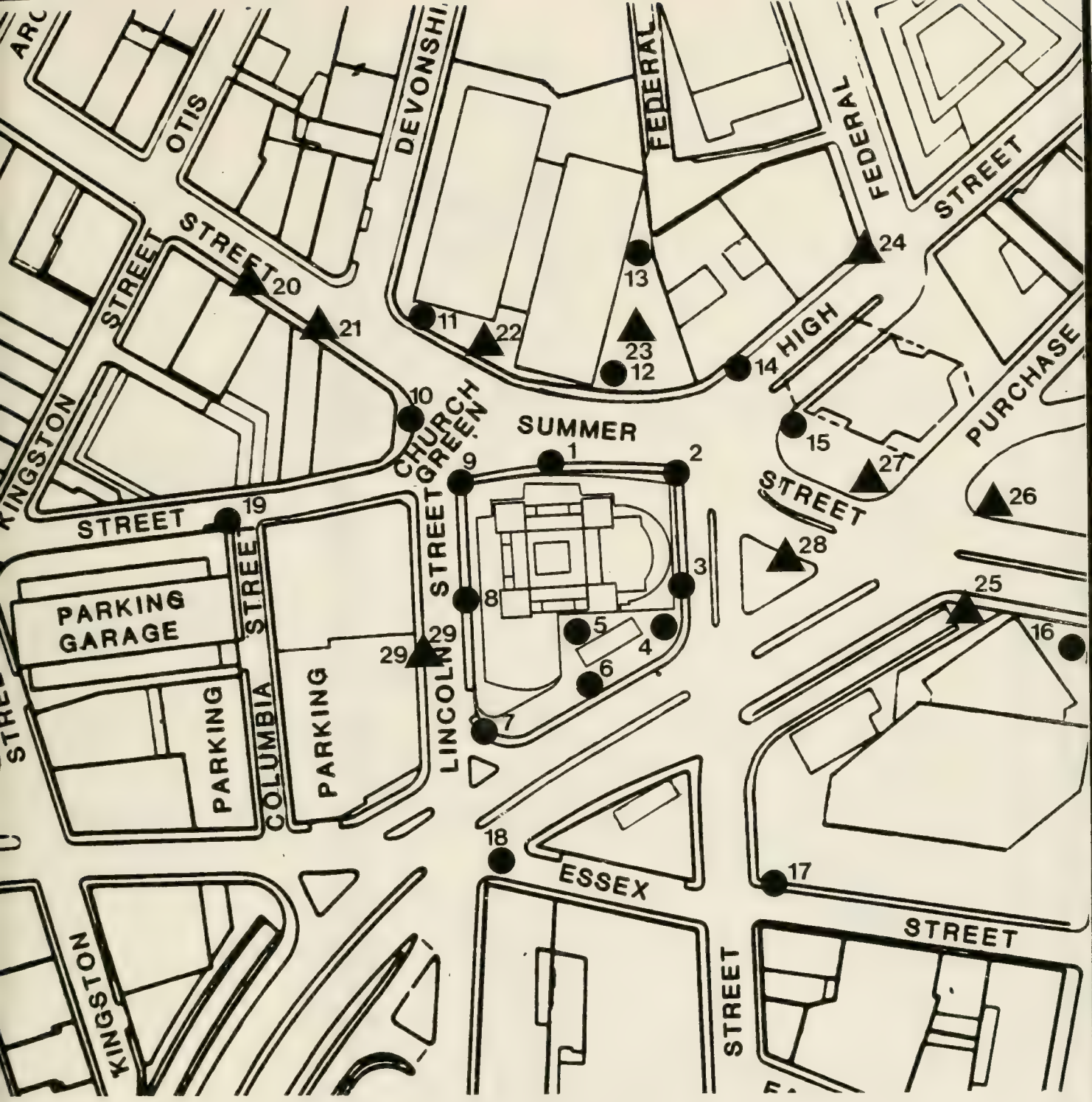


FIGURE 4.1-19 STUDY LOCATIONS FOR QUANTITATIVE ANALYSIS

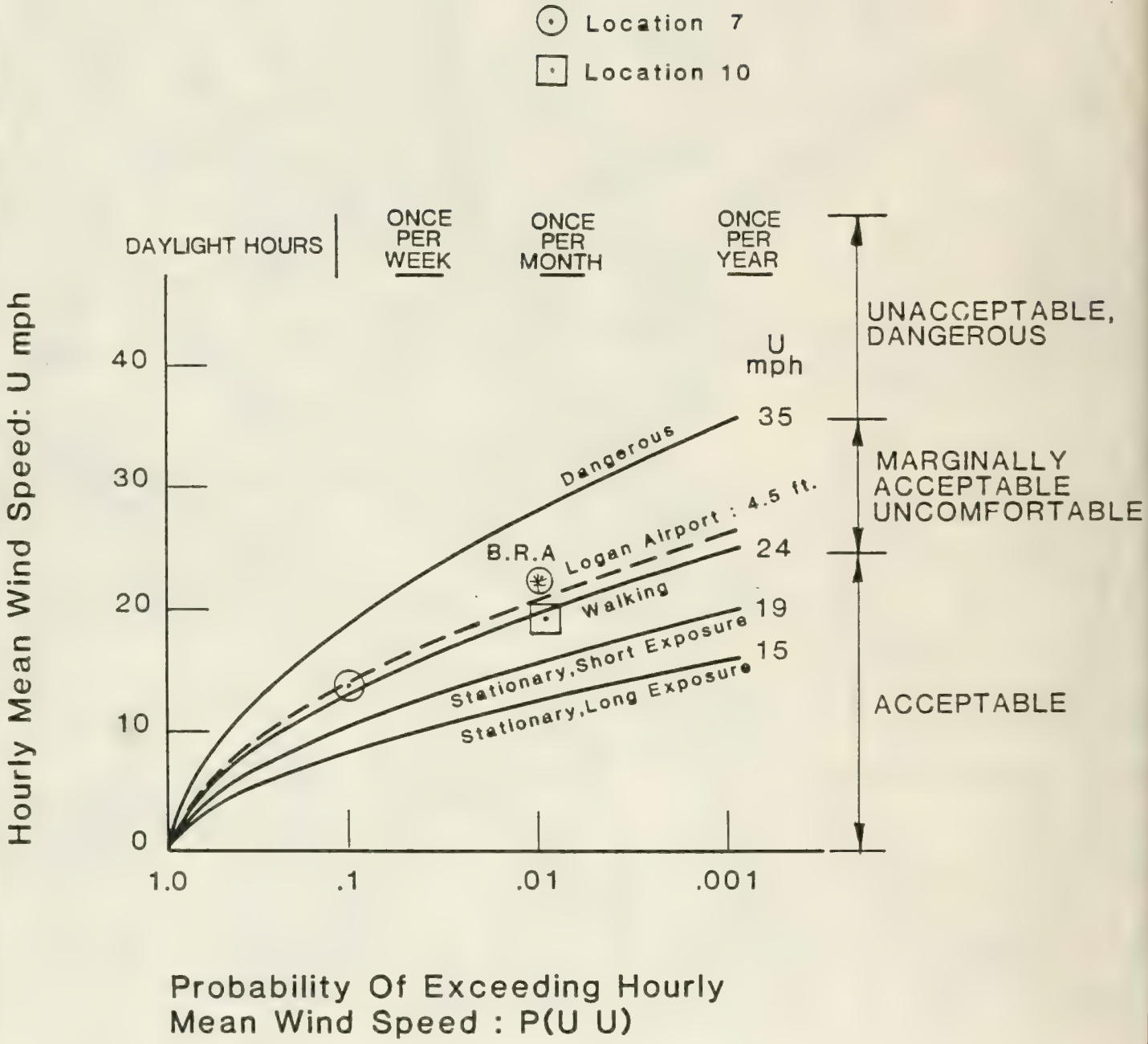
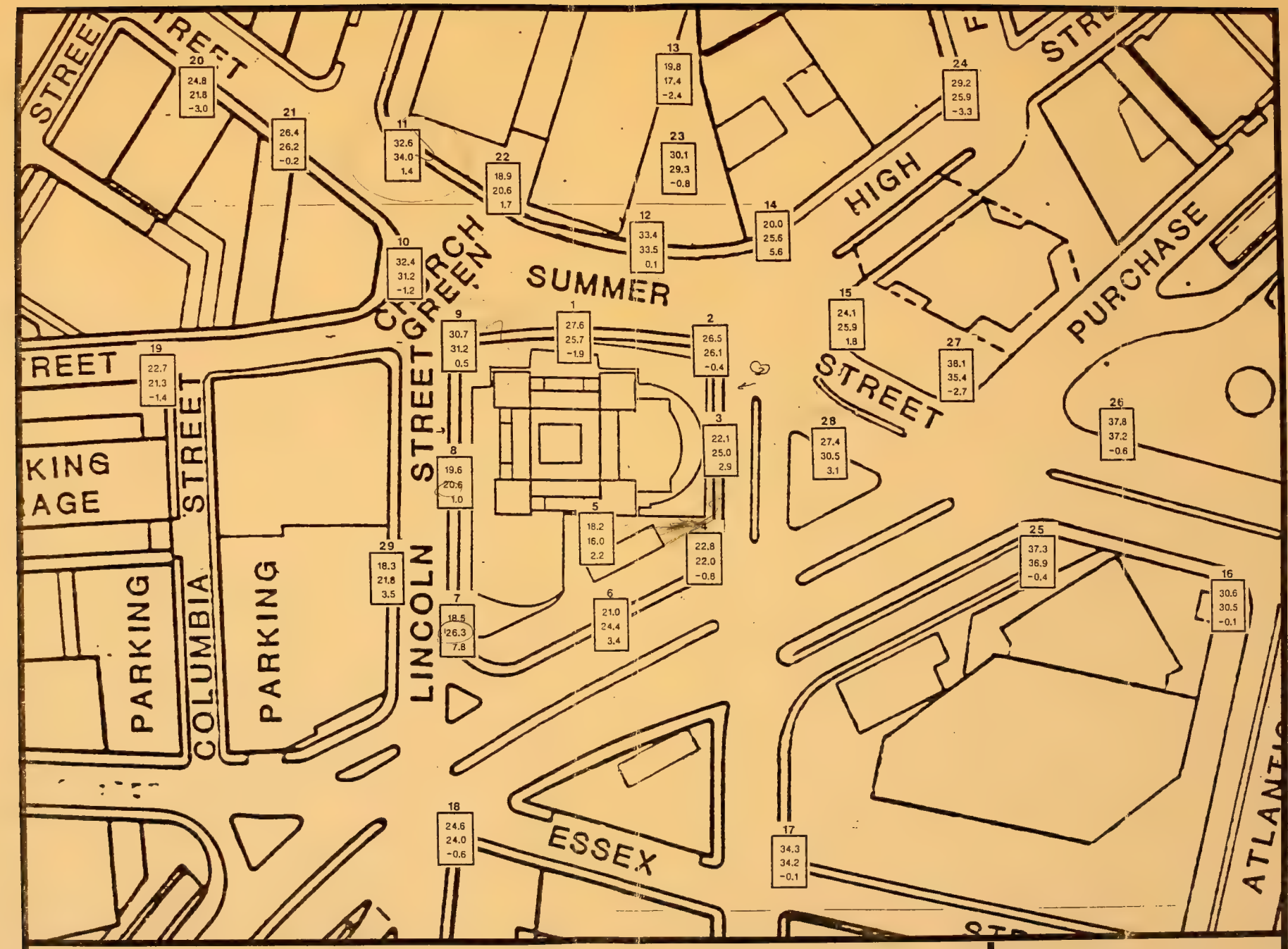


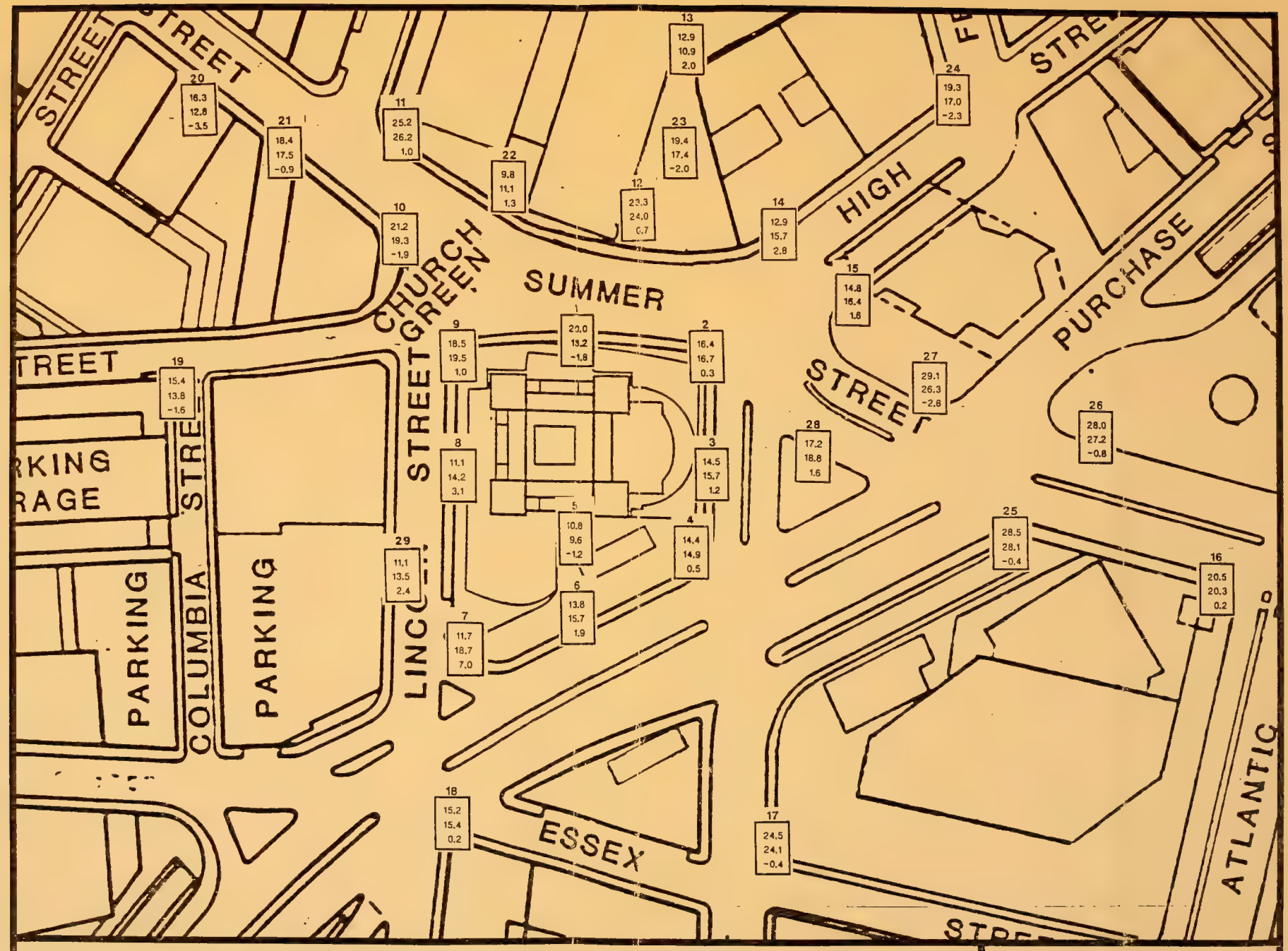
FIGURE 4.1-20 LOCATIONS 7 AND 28 COMPARED TO MELBOURNE'S CRITERIA FOR AVERAGE HOURLY PEDESTRIAN WINDS COMPARED WITH OTHER REFERENCES



MEAN WIND SPEEDS EXCEEDING 1% OF THE TIME

FIGURE 4.1-21

XX LOCATION
XX NO BUILD
XX BUILD
XX DIFFERENCE



GUST WIND SPEEDS EXCEEDING 1% OF THE TIME

FIGURE 4.1-22

4.2 SHADOW IMPACT

Shadow diagrams were compiled depicting new shadows associated with the 125 Summer Street project. Shadows for each season were studied as follows: summer (June 22); peak winter shadow (December 22); and spring and fall equinox (March 21/September 23). For each of these times of year representative morning (9:00 AM), noon, and afternoon (3:00 PM) shadow patterns were calculated. Additional shadow analyses were also conducted for 10:00 AM through 2:00 PM at hourly increments for October 21 and November 21 to determine the project's ability to preserve sunlight at existing sunny public spaces. In general, all shadows from individual buildings are short in length during the summer as a result of the higher solar altitude angle. Figure 4.2-1 demonstrates this by comparing the effect of solar altitude angle on shadow length at noontime for the summer, spring/fall, and winter analysis cases.

During the spring and fall equinox, shadows extend further from a building's base as the solar altitude angle is less than at summer. At the same time the lateral angle through wich shadows sweep from morning to evening decrease as shown in Figure 4.2-2. Shadow diagrams for each day/hour analysis combination are presented at the end of this section. The nineteen figures present the horizontal shadow profile for each scenario. The shadow profile of the proposed building is shown by a broken line while existing profiles are outlined with a solid line. The diagrams also show, in a dot-pattern, existing shadows while net new shadows associated with introduction of the proposed project are indicated by the darker pattern. The net new shadow is essentially the measure of the project's shadow impact as it depicts the areas in which new shadows fall on previously sunny locations. Those areas within the profile of the proposed project (broken line) that are shown with the dot-pattern, represent areas where shadows of the project overlap with shadows of existing buildings.

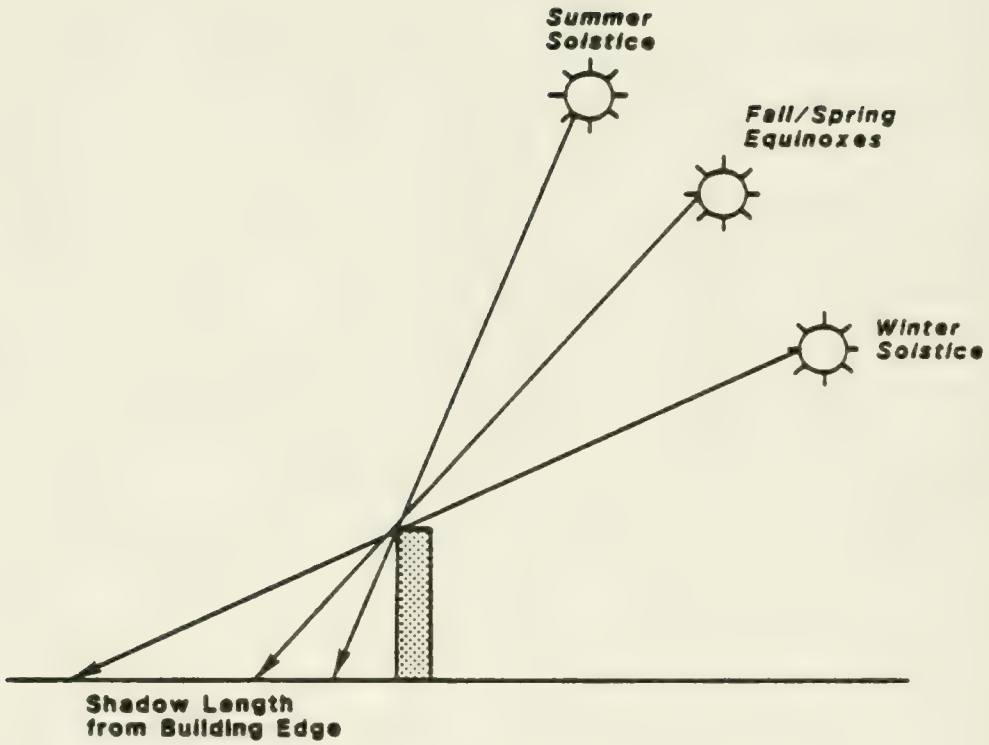


FIGURE 4.2-1 NOONTIME SOLAR ALTITUDE ANGLES

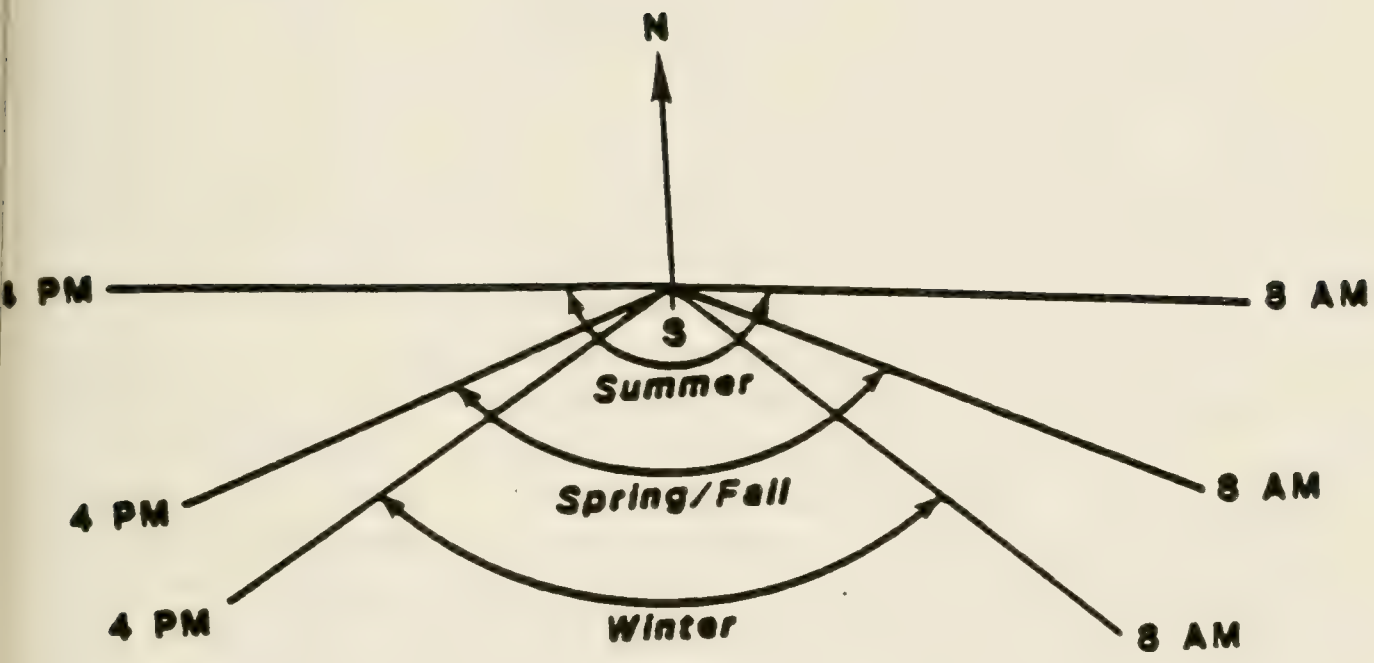


FIGURE 4.2-2 LATERAL SWEEP OF SUN'S PATH BY SEASON
(8 AM - 4 PM)

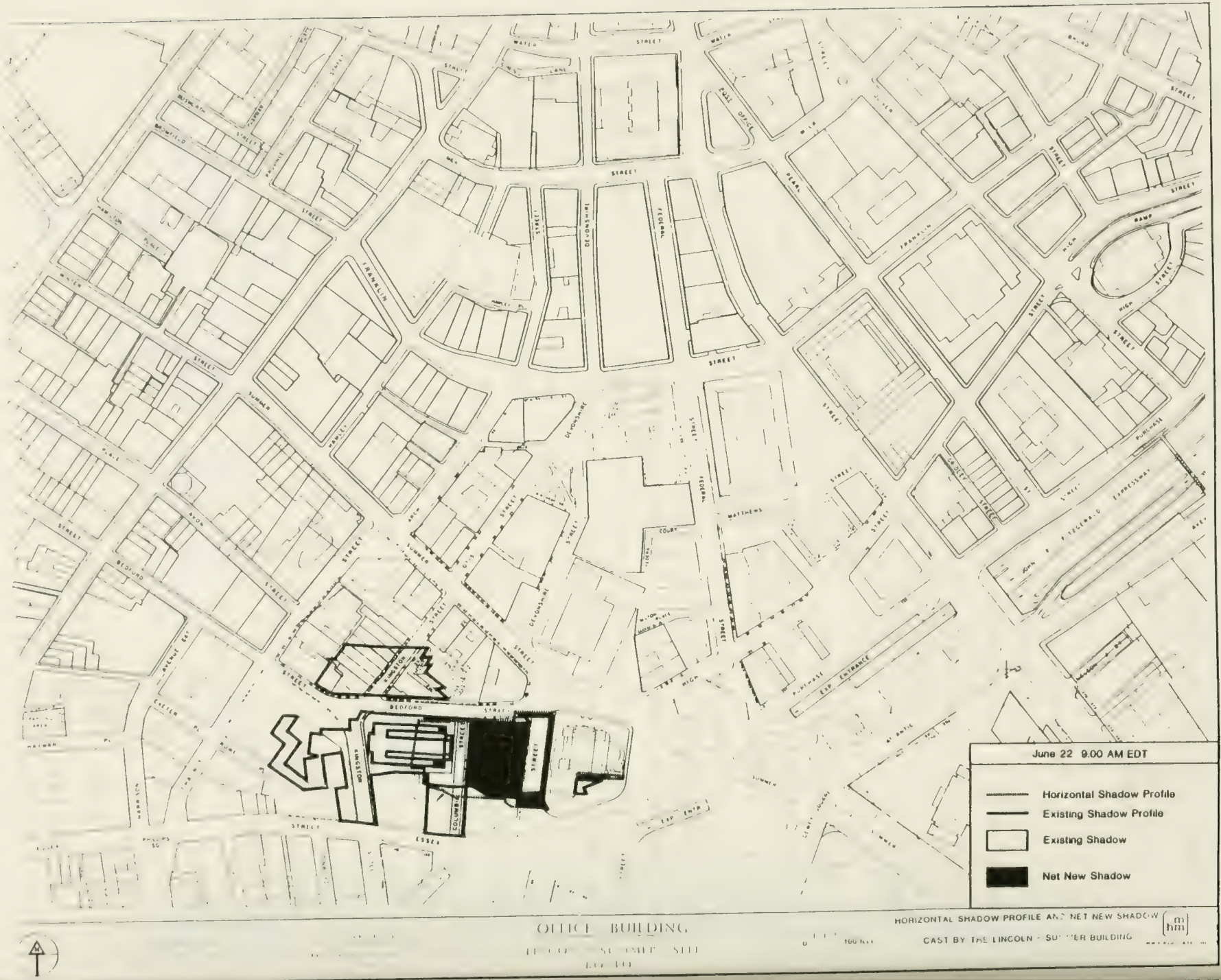
During the summer, when people are frequently outdoors, shadow impacts are primarily limited to the streets adjacent to the project site. Since existing buildings on the project site already shade the walkways and the halves of streets closest to the project site, net new summer shadows only occur at the opposite half of adjacent streets. During the morning hours net new shadows primarily occur at rooftops and a small area of Lincoln Street at the southwest corner of the project site. By noontime a small amount of additional shading is expected along the opposite sides of Lincoln and High Streets around the northwest corner of the proposed project. During the afternoon hours net new shadows are expected at the intersection of Summer, High and South Streets; extending to the west corner of the Fiduciary Trust Building. Net new shadows associated with the project at the spring and fall equinox are limited entirely to a small area of rooftop during the mid-morning hours. As noon approaches new shadows will be evident at the opposite halves of Lincoln and Summer Streets along the northwest corner of the project. These shadows will extend to the southwest side of the 100 Summer Street building. By noontime and through early afternoon net new shadows are primarily limited to the southern side of 100 Summer Street. During the early and mid-afternoon hours some new shading is anticipated at the southern half of the open plaza area on the east side of the 100 Summer Street building.

During winter, shadows reach maximum lengths such that most pedestrian level locations are shaded by existing buildings. During the morning hours, net new shadows from the proposed 125 Summer Street project will be found primarily on rooftops. At noontime, net new shadow is only expected at the northern wedge of the plaza on the east side of the 100 Summer Street buildling. By mid-afternoon, only minimal net new shadow is expected at pedestrian levels.

During mid-autumn, represented by the October 21 shadow diagrams, the shadow profile of the project begins to extend about 400 feet (daily average) from the project site. During the mid-morning hours, new shadows will be found on rooftops and only a small area of Lincoln Street adjacent to the southwest corner of the project. By late morning and noontime, net new shadows are limited to the area near the intersection of Summer and Devonshire Streets and along the southwest side of 100 Summer Street. During the early and mid-afternoon hours the bulk of the new shadows is expected at the plaza area on the east side of the 100 Summer Street building.

During late autumn, represented by November 21, net new shadows of the proposed building are significantly reduced due to the longer shadows of adjacent buildings. During morning hours most net new shading of pedestrian areas occurs in the vicinity of the Summer and Devonshire Street intersection. At noontime and during the very early afternoon net new shadows will primarily be limited to the northern wedge of the 100 Summer Street Plaza area. By mid-afternoon (around 2:00 PM) most net new shadows are only expected at rooftops and building facades to the northeast of the project site.

In summary, shadow diagrams demonstrate the majority of net new shadow generated at pedestrian levels adjacent to the project and some rooftops away from the project site. Most noticeable impacts are anticipated during the late spring and early fall. Areas impacted during this period will primarily include High Street during the morning, the pedestrian way along the southwest side of 100 Summer Street at noon, and portions of the plaza area on the east side of 100 Summer Street during early and mid-afternoon. Additional shading to the 100 Summer Street Plaza area is expected for any proposed building at the project site greater than the height of existing buildings. Furthermore, the existing low-rise base partially shades the plaza area already. Shadows during hot summer days are generally welcomed by pedestrians and by late fall through early spring the project area is already heavily shaded under existing conditions.


June 22 9.00 AM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUDBURY BUILDING

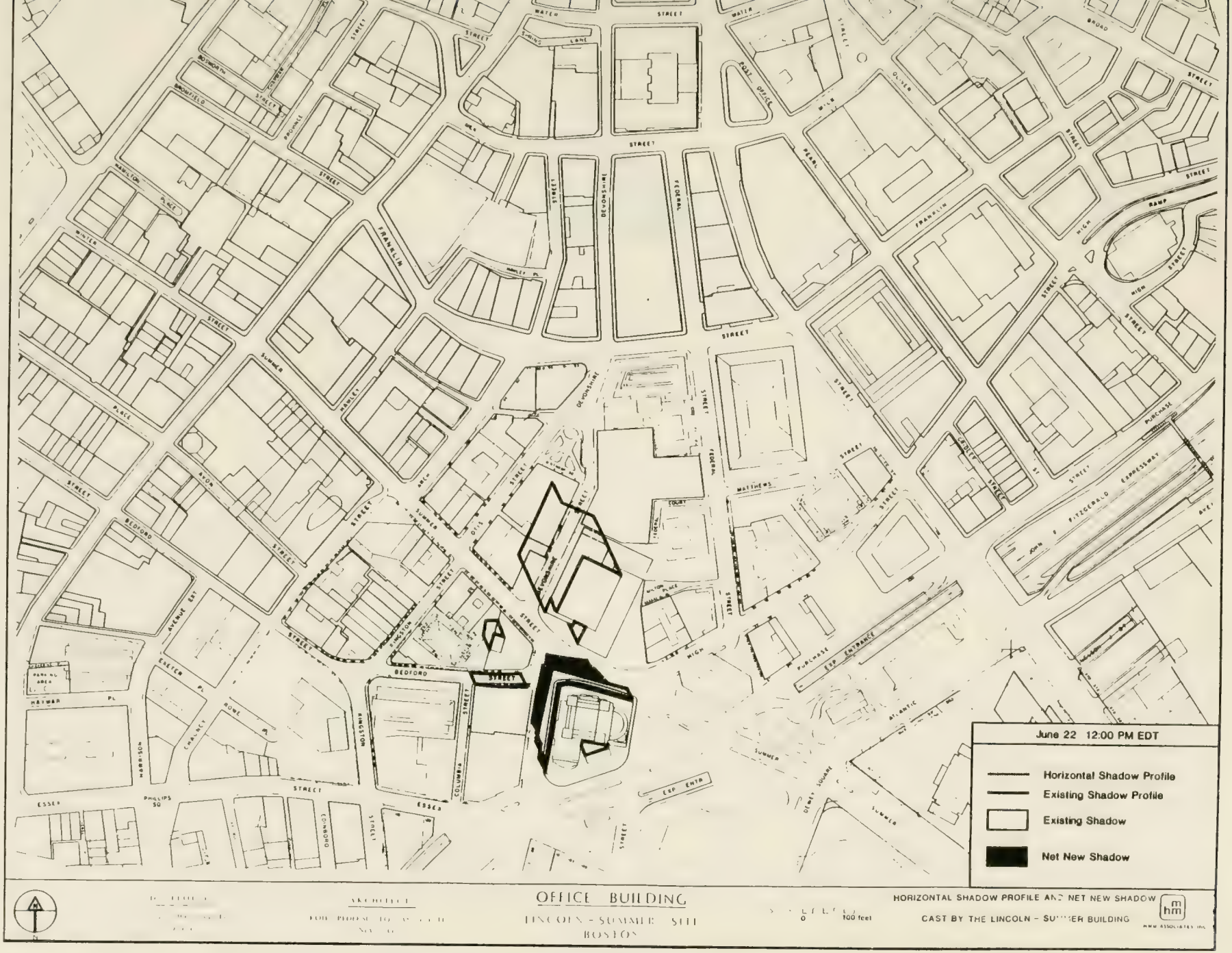
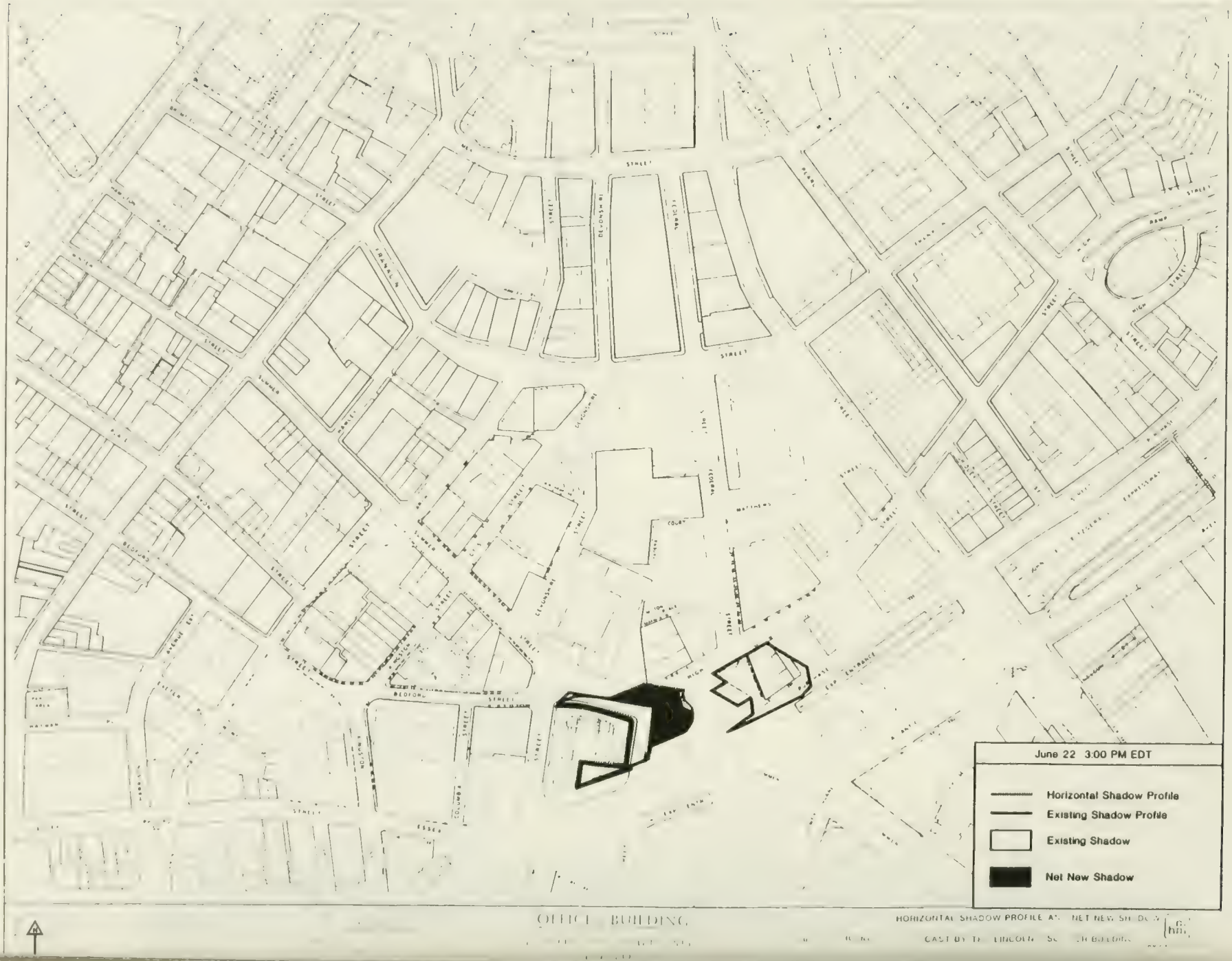


FIGURE 4.2-4 HORIZONTAL SHADOW PROFILE

JUNE 22 12:00 PM EDT


June 22 3:00 PM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow

4.2-8

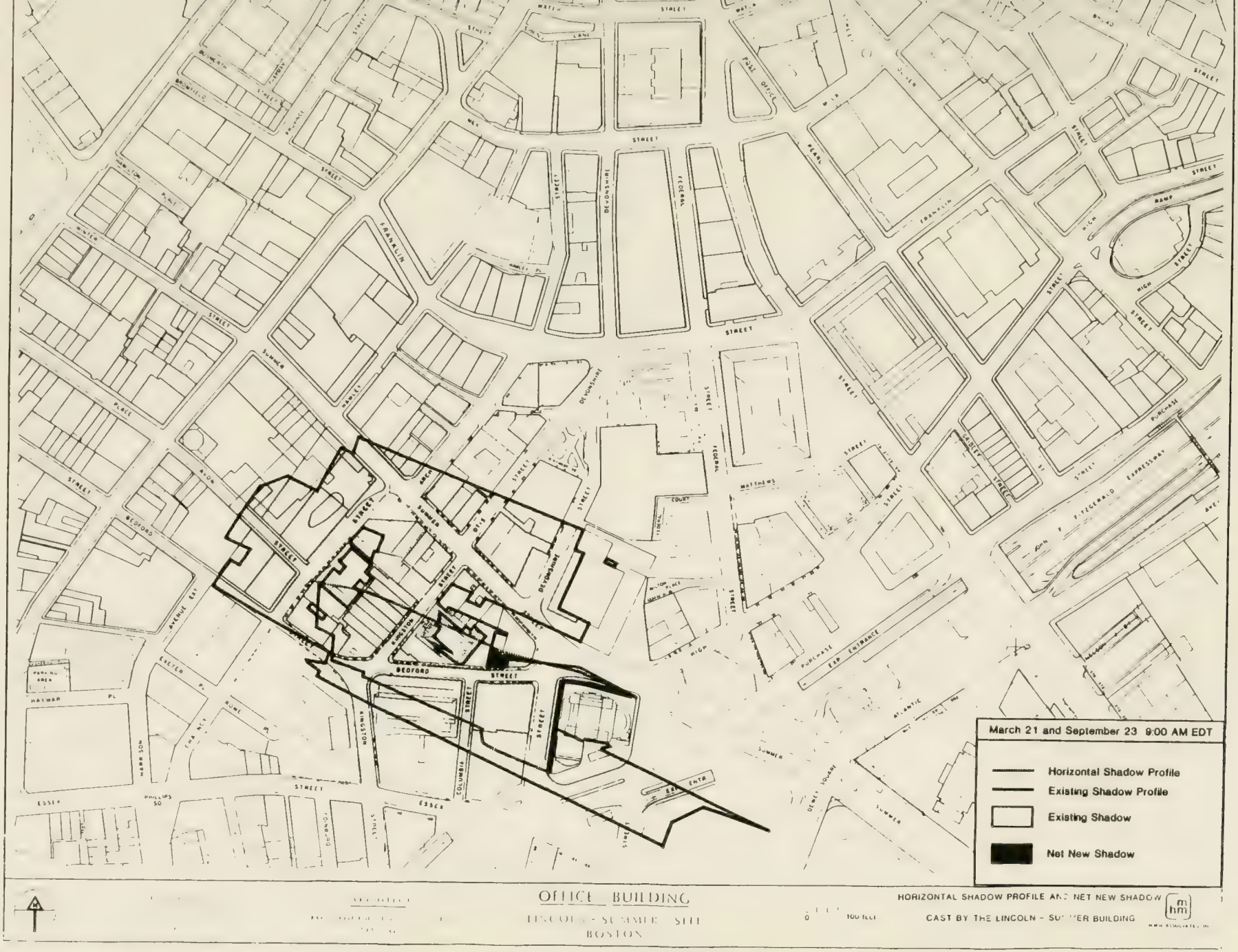


FIGURE 4.2-6 HORIZONTAL SHADOW PROFILE
MARCH 21 AND SEPTEMBER 23 9:00 AM EDT

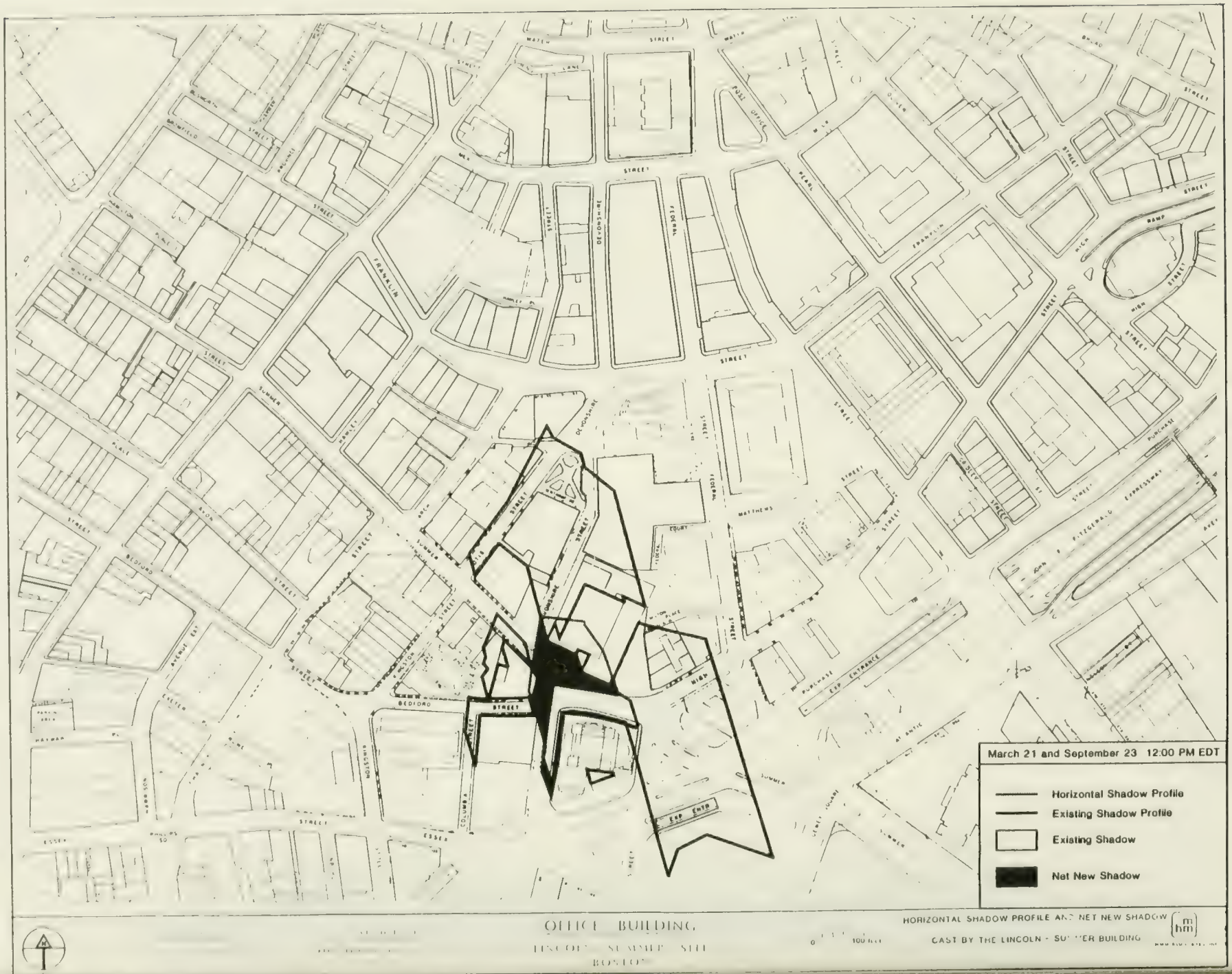
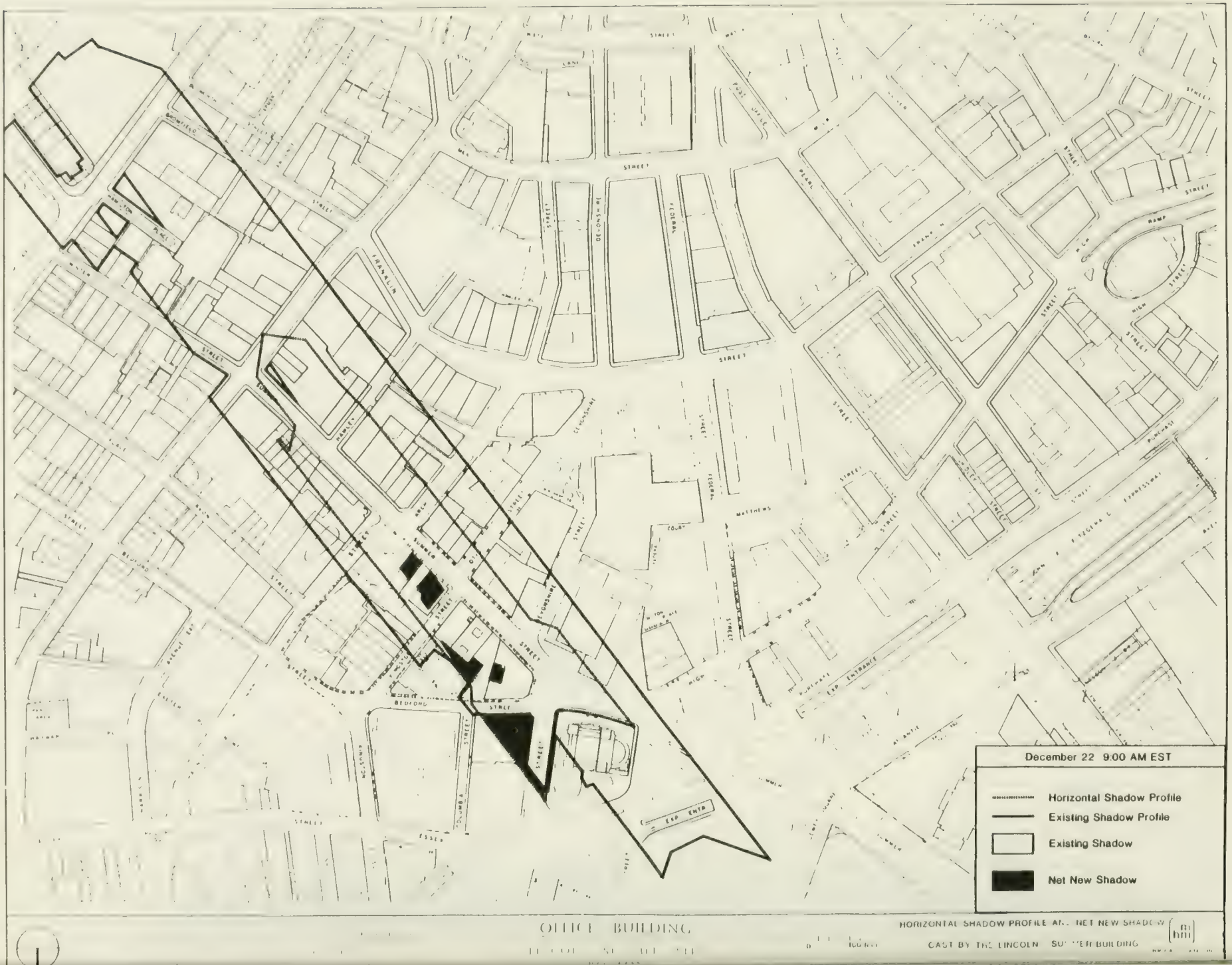

March 21 and September 23 12:00 PM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING,
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUMMER BUILDING

FIGURE 4.2-8 HORIZONTAL SHADOW PROFILE
MARCH 21 AND SEPTEMBER 23 3:00 PM EDT


December 22 9:00 AM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN SOUTH BUILDING

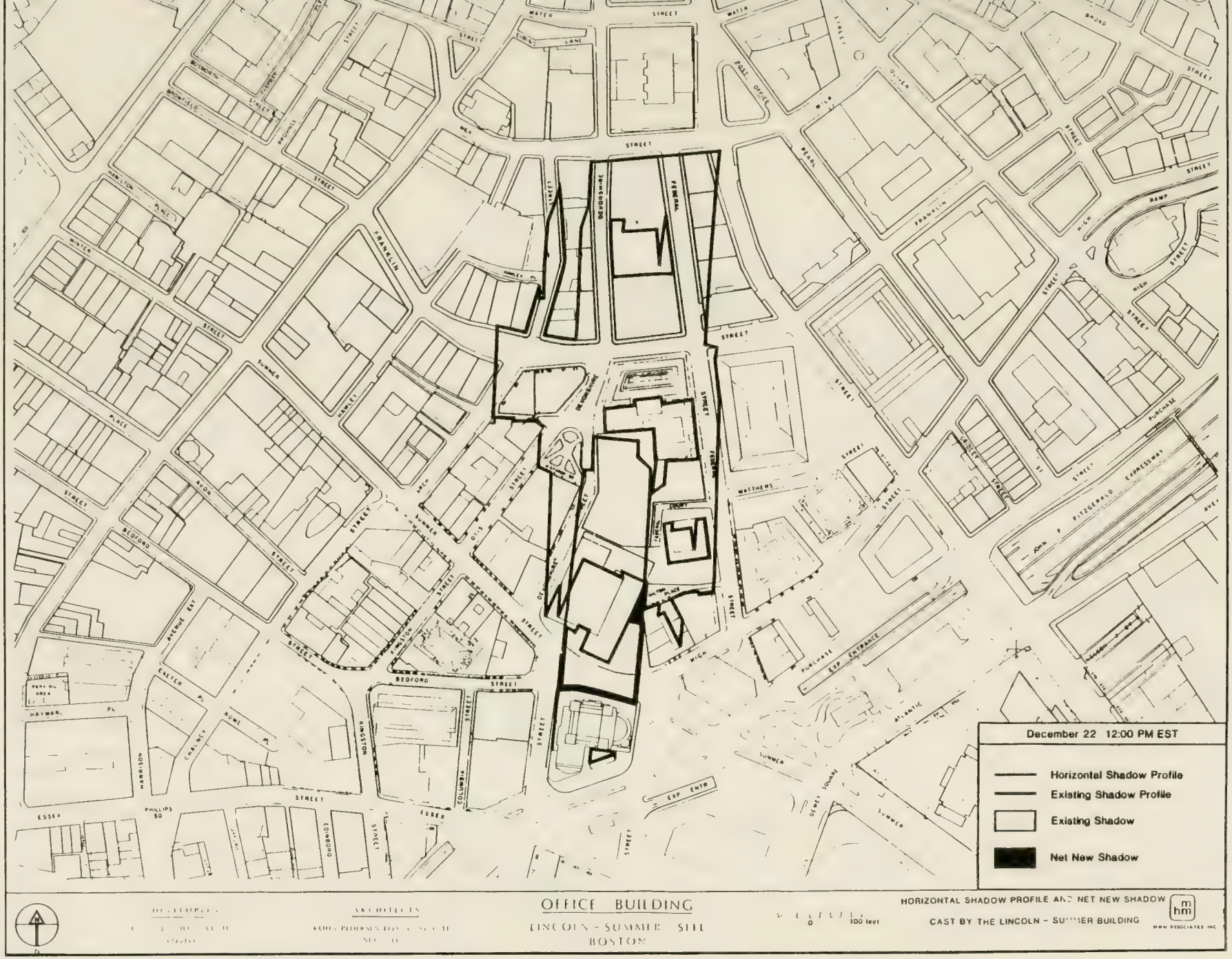
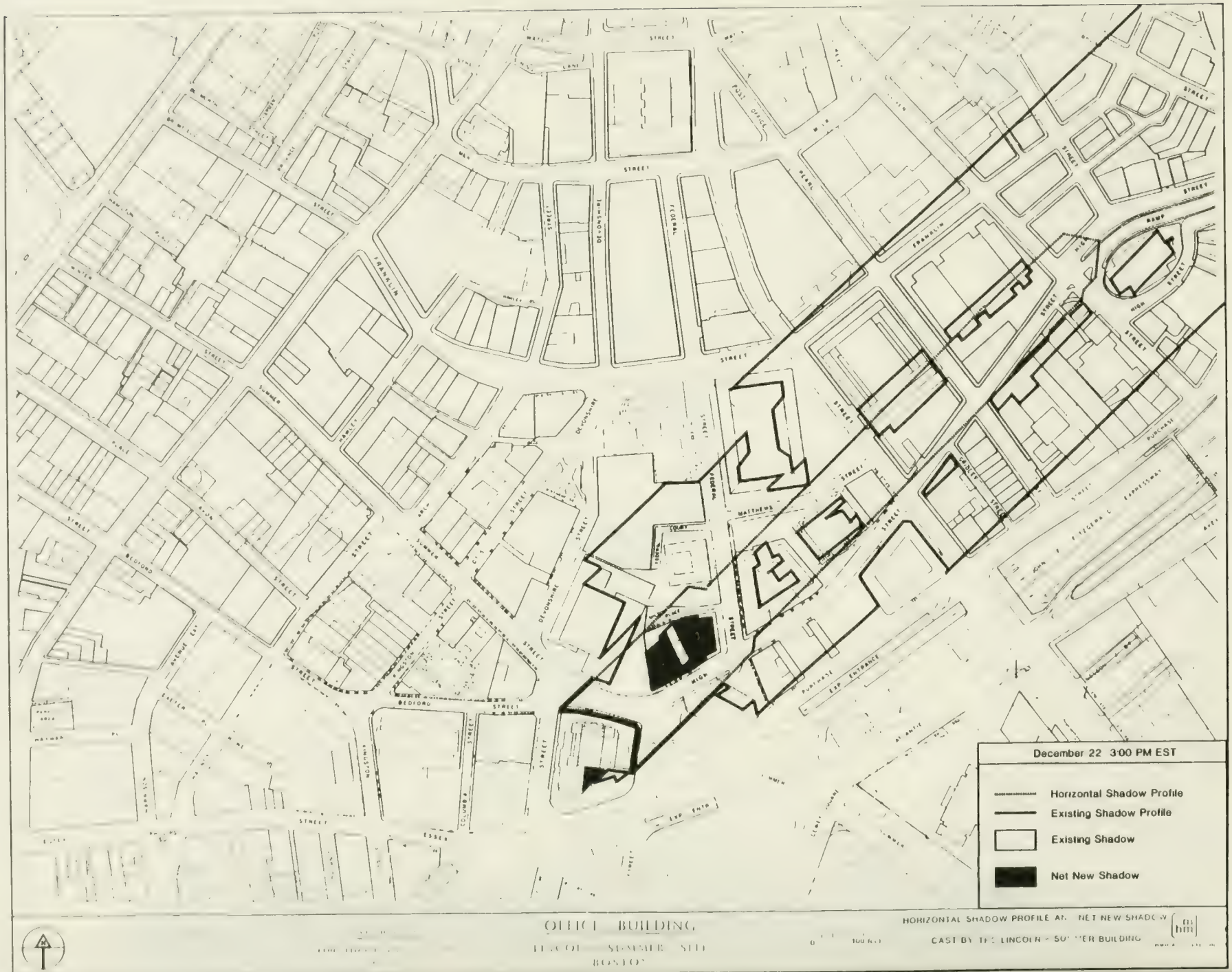


FIGURE 4.2-10 HORIZONTAL SHADOW PROFILE
DECEMBER 22 12:00 PM EST


December 22 3:00 PM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
BOSTON
HORIZONTAL SHADOW PROFILE AN NET NEW SHADOW
CAST BY THE LINCOLN - SOUTHER BUILDING

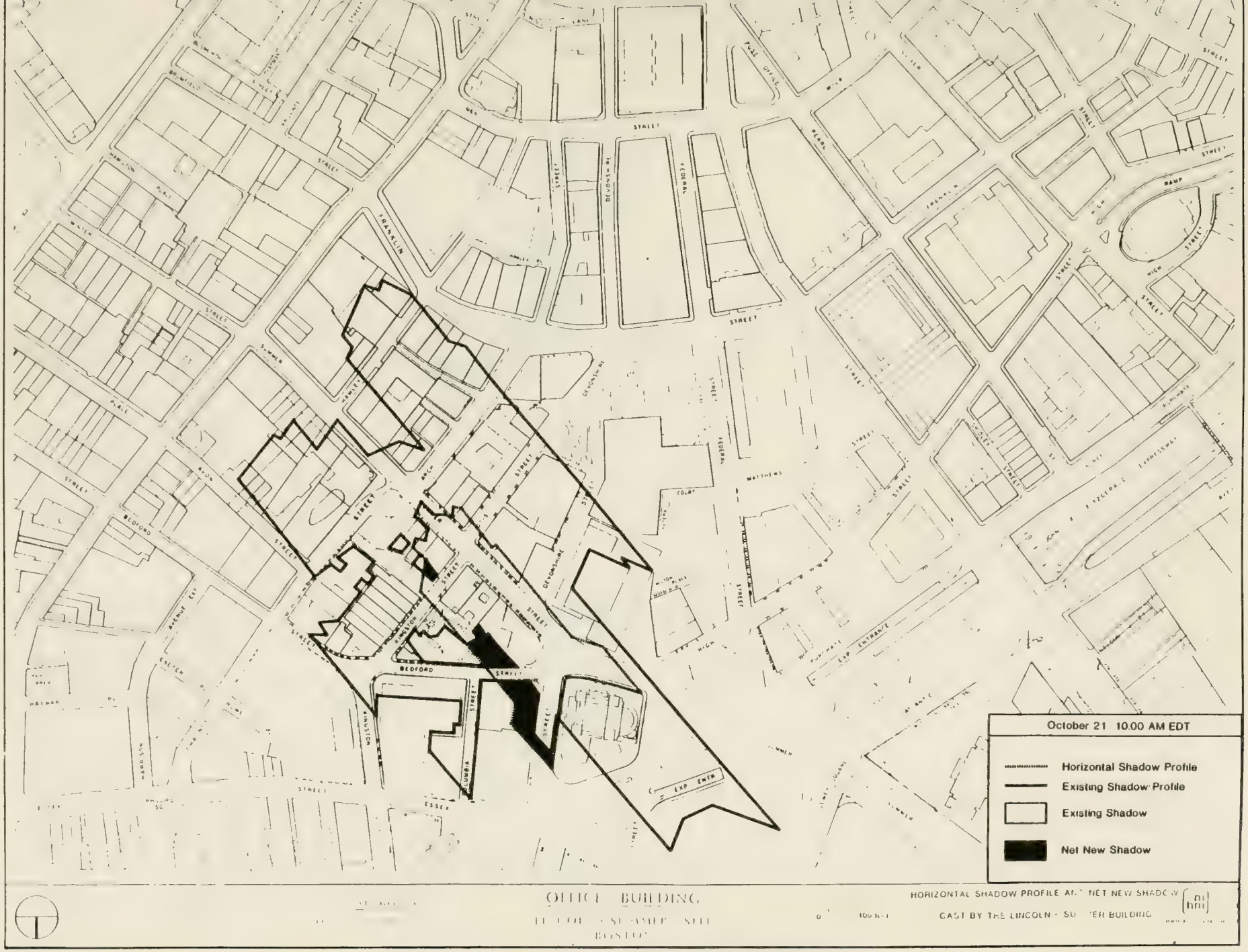

October 21 10.00 AM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUDBURY BUILDING

FIGURE 4.2-12 HORIZONTAL SHADOW PROFILE

October 21 11:00 AM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUDBURY BUILDING

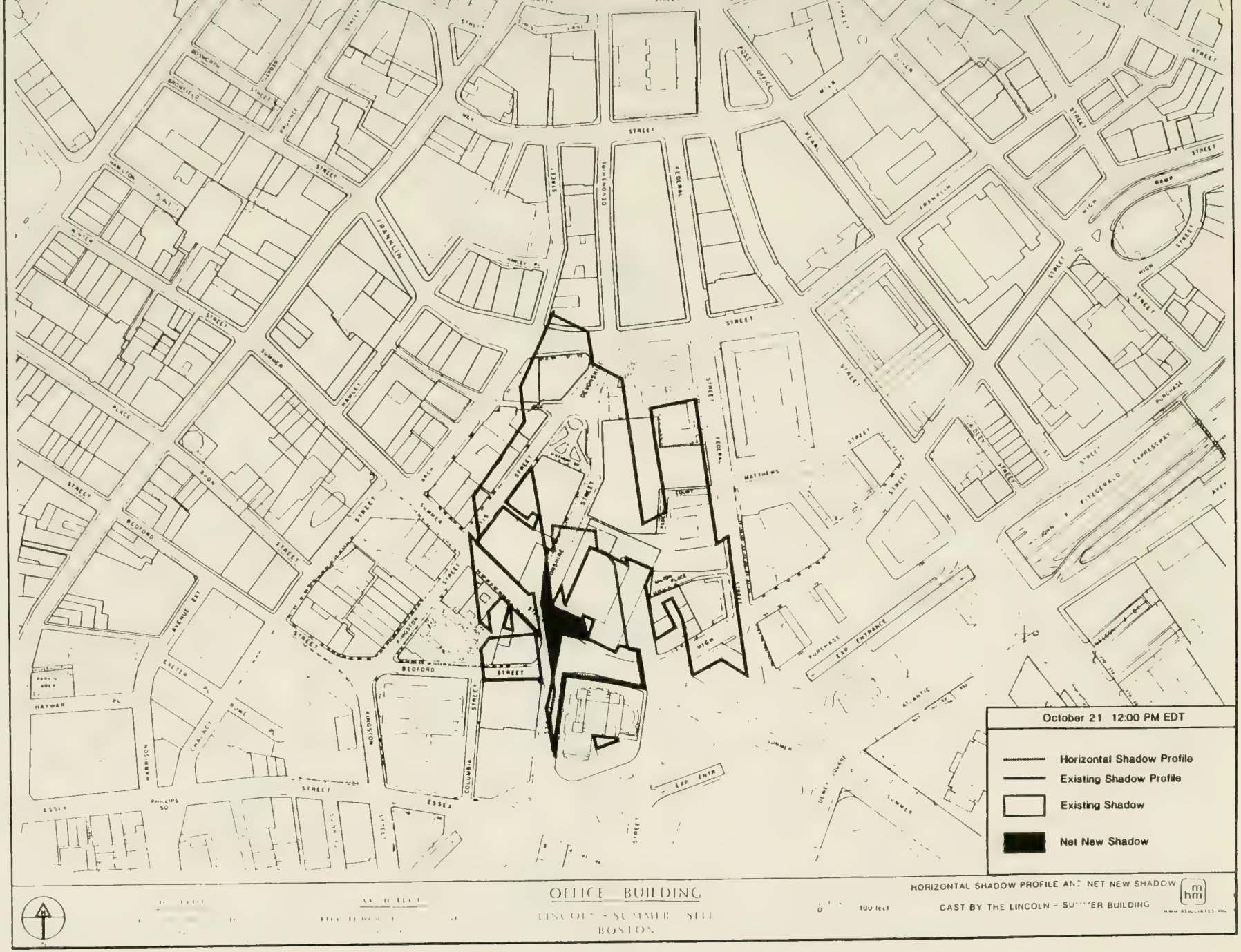
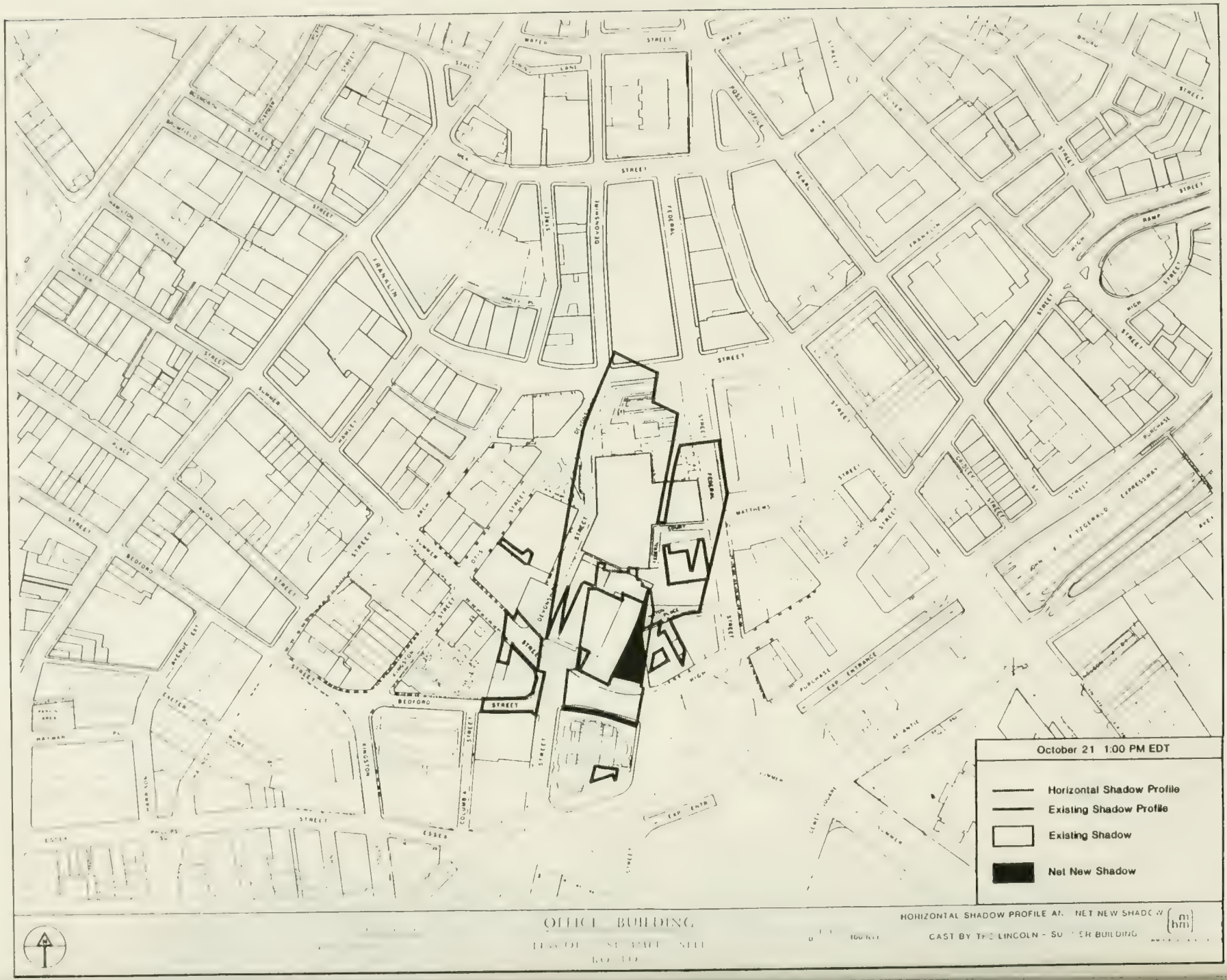


FIGURE 4.2-14 HORIZONTAL SHADOW PROFILE
OCTOBER 21 12:00 PM EDT


October 21 1:00 PM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUDBURY BUILDING

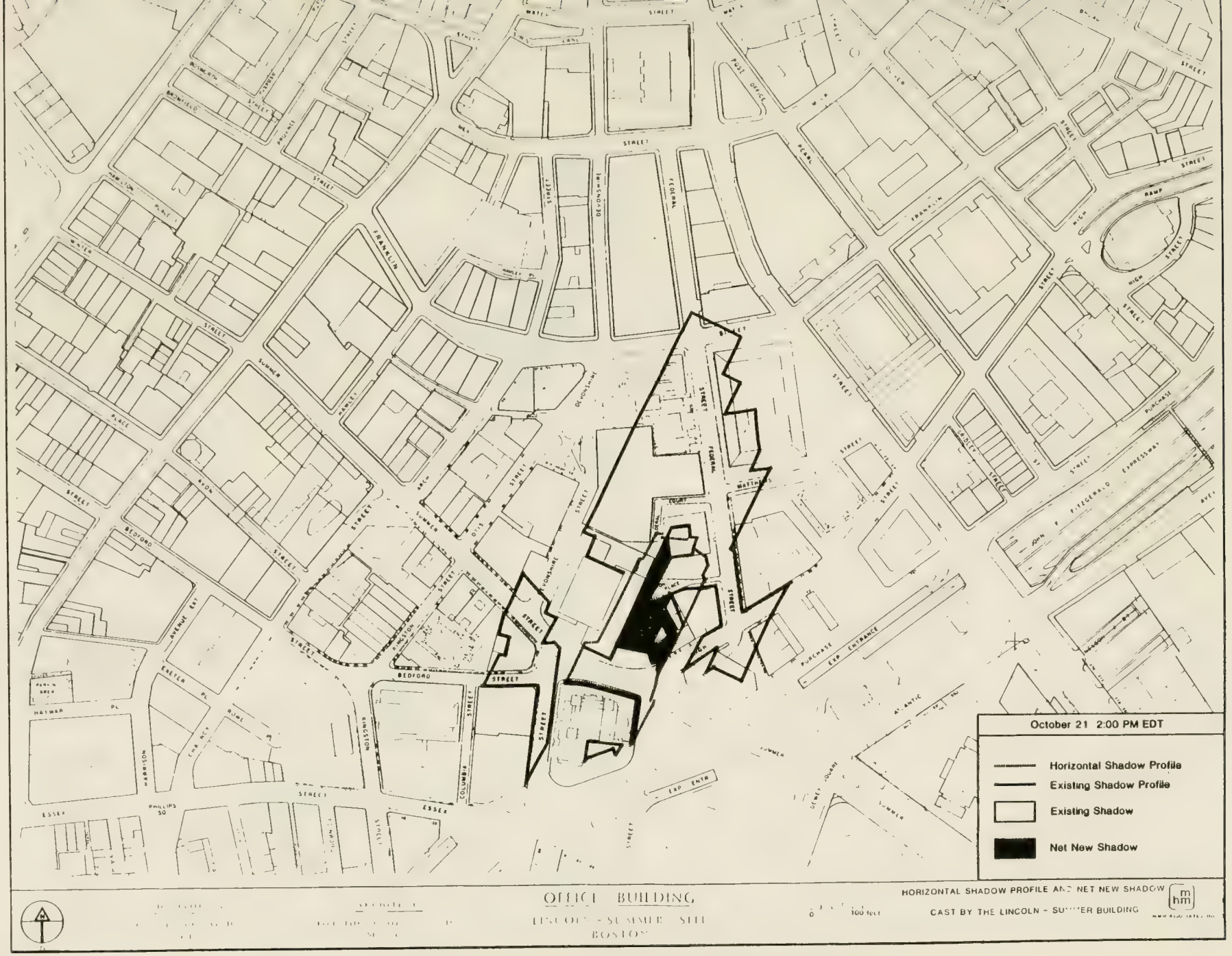
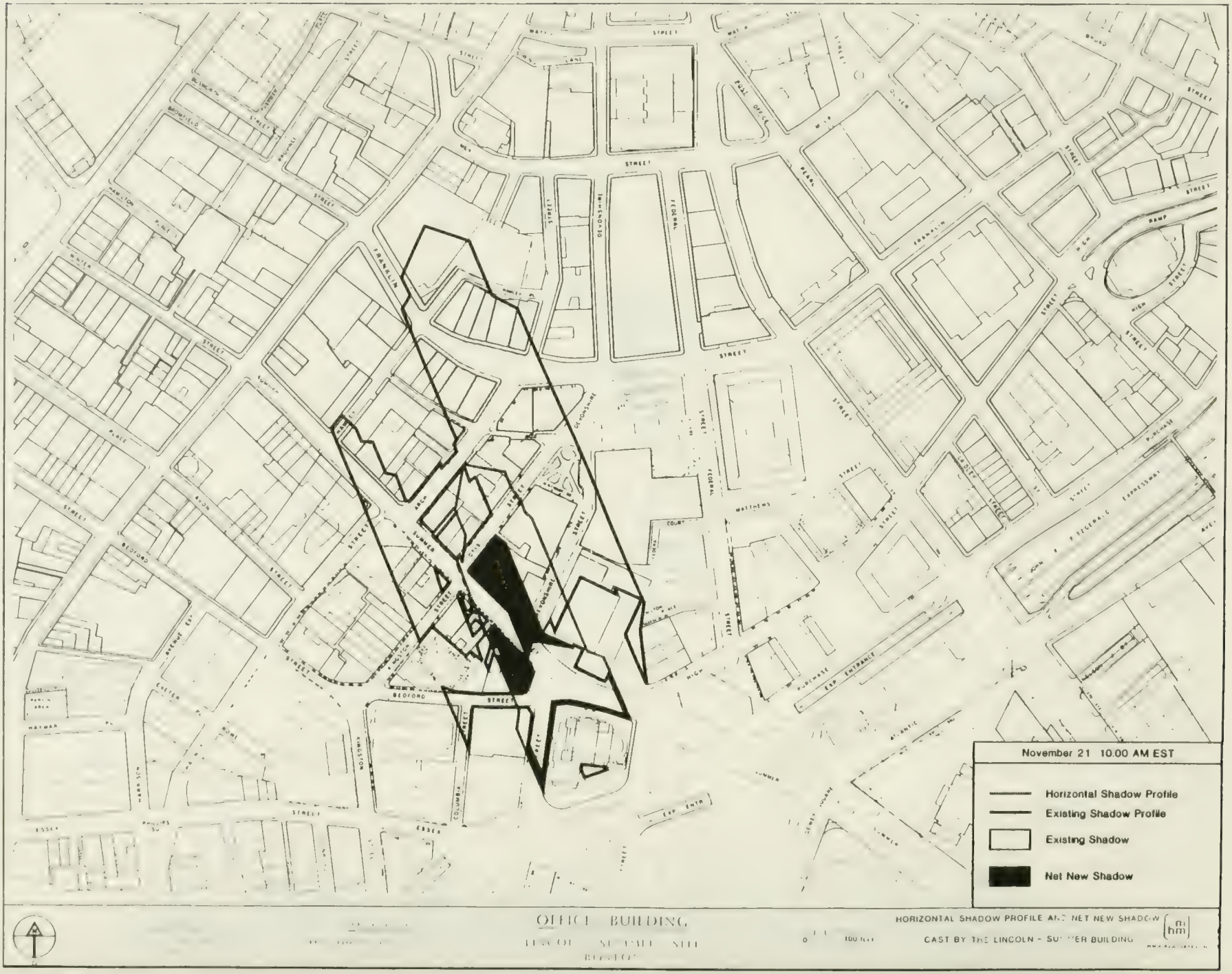


FIGURE 4.2-16 HORIZONTAL SHADOW PROFILE
OCTOBER 21 2:00 PM EDT


November 21 10.00 AM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUMMER BUILDING

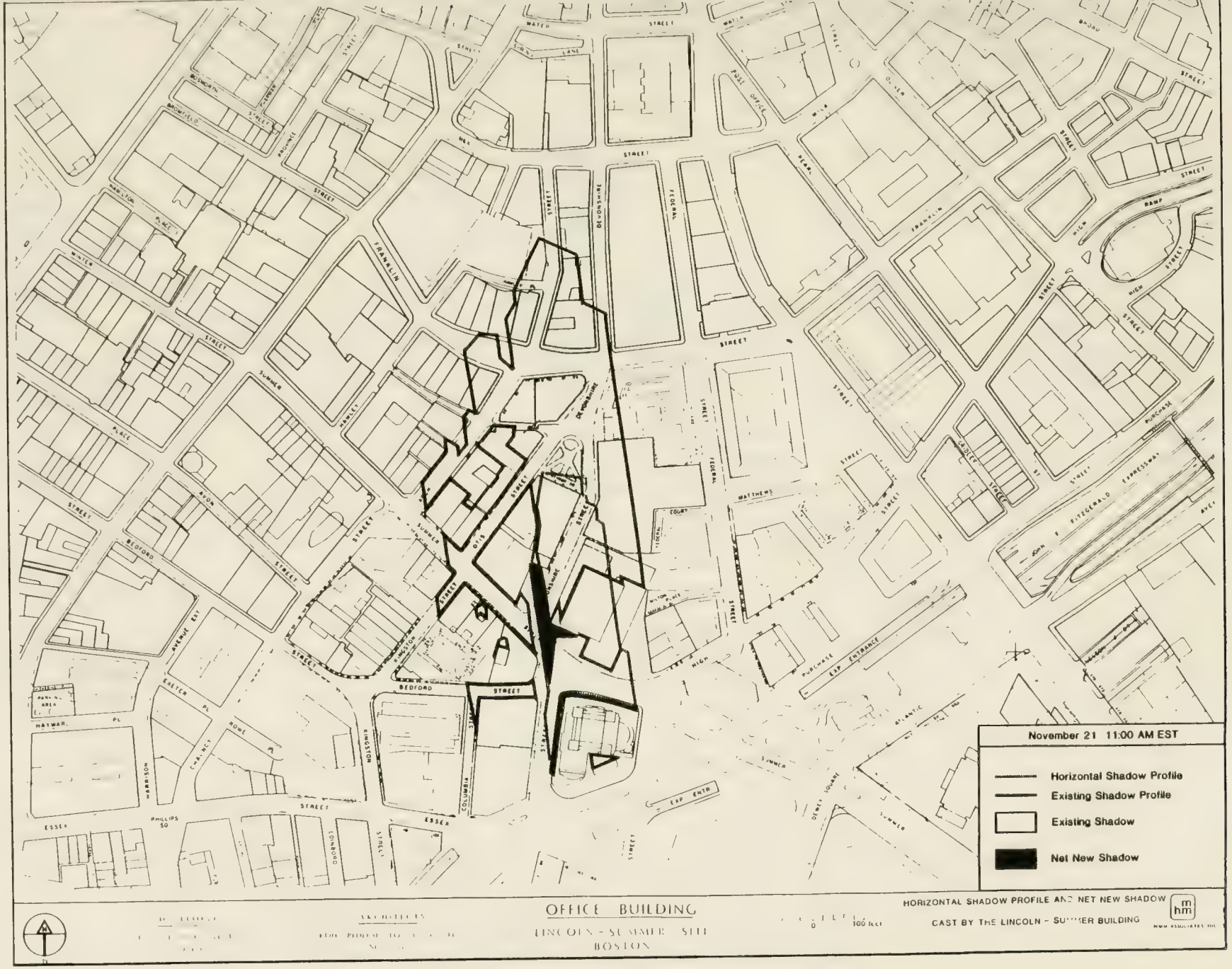
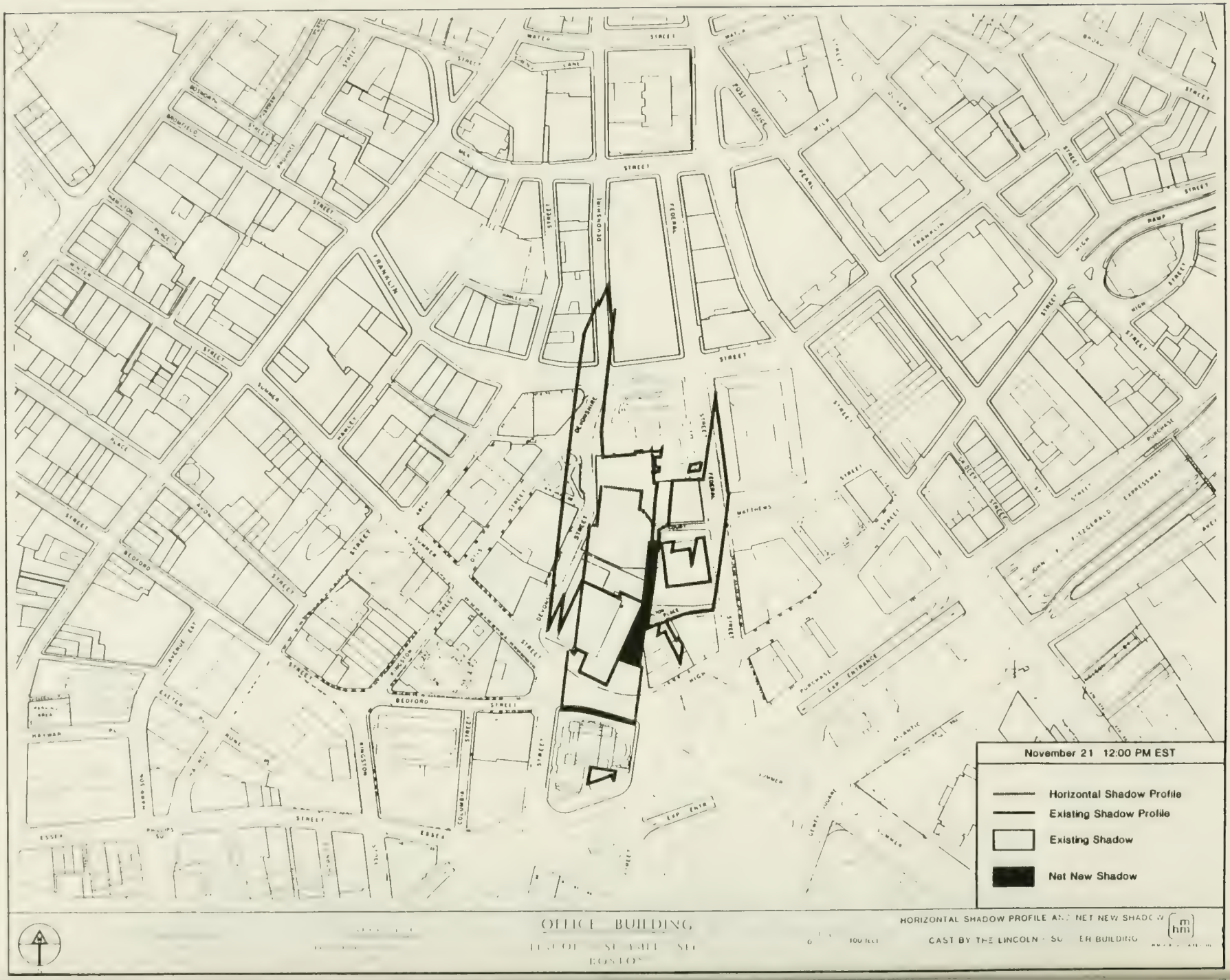
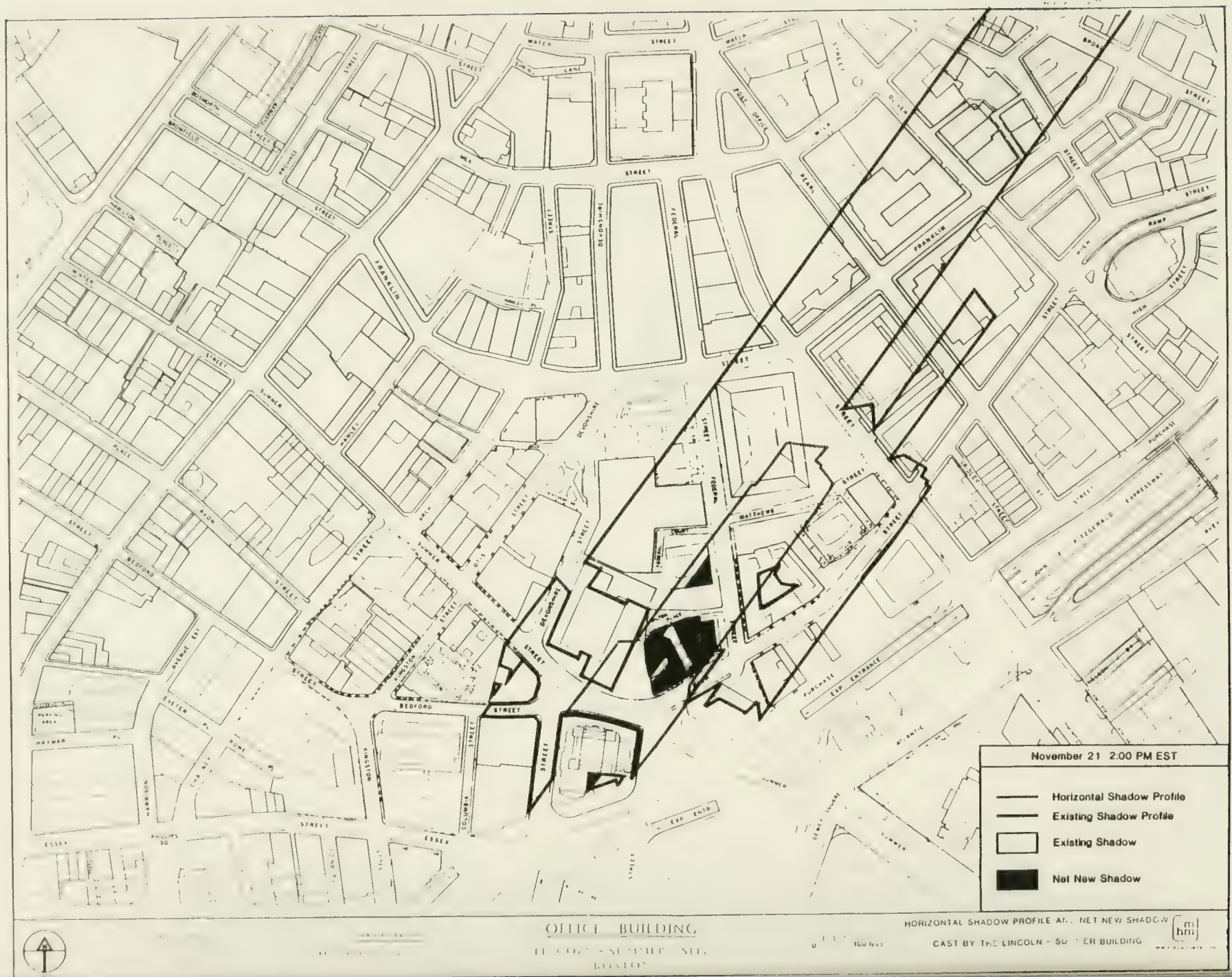


FIGURE 4.2-18 HORIZONTAL SHADOW PROFILE
NOVEMBER 21 11:00 AM EST


November 21 12:00 PM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUMMER BUILDING

November 21 1:00 PM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SOUTHER BUILDING

FIGURE 4.2-20 HORIZONTAL SHADOW PROFILE
NOVEMBER 21 1:00 PM EST


November 21 2:00 PM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUDBURY BUILDING

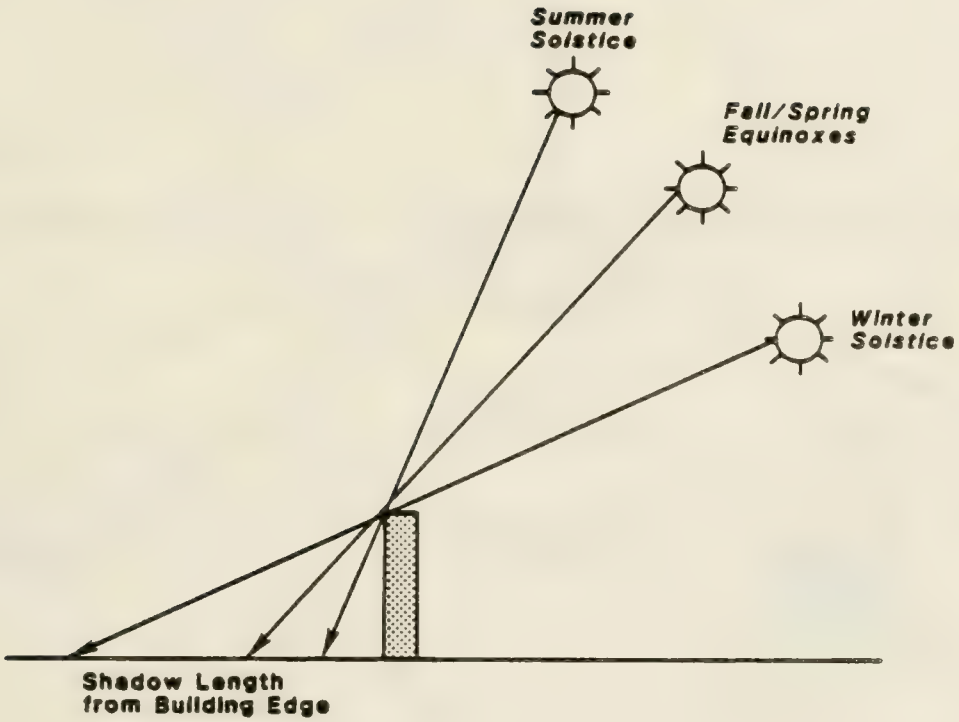


FIGURE 4.2-1 NOONTIME SOLAR ALTITUDE ANGLES

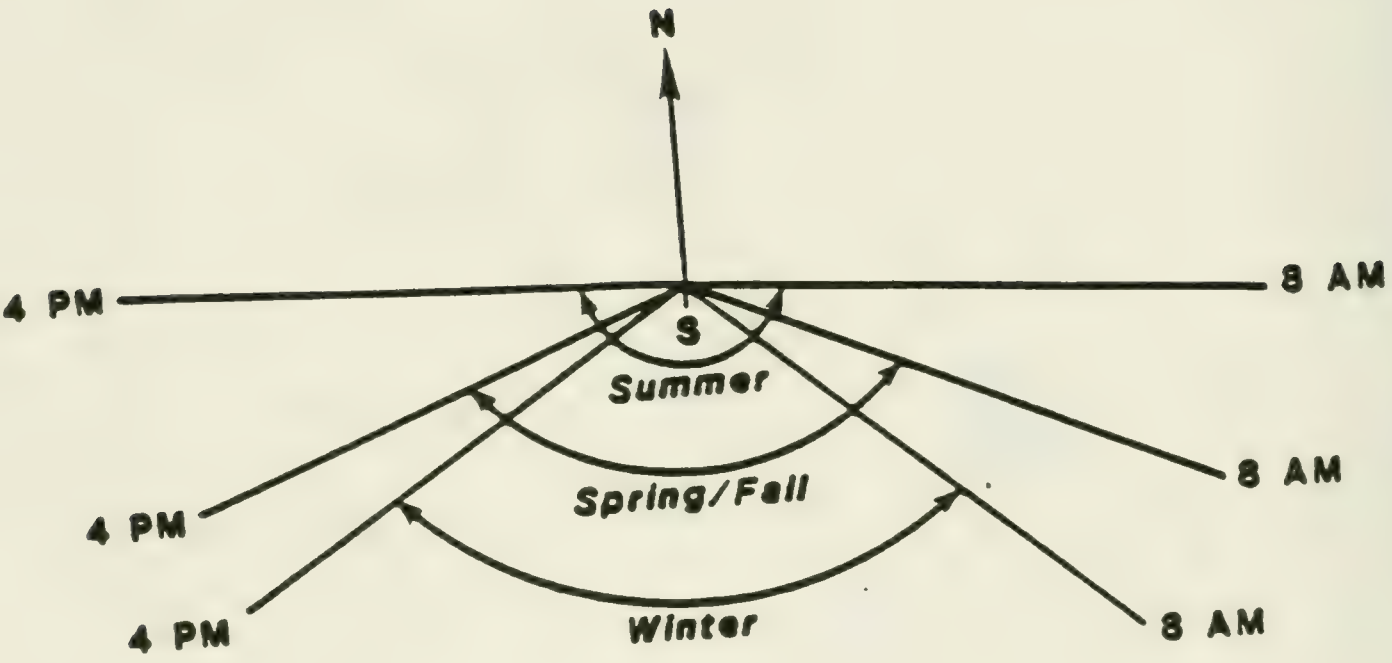


FIGURE 4.2-2 LATERAL SWEEP OF SUN'S PATH BY SEASON
(8 AM - 4 PM)

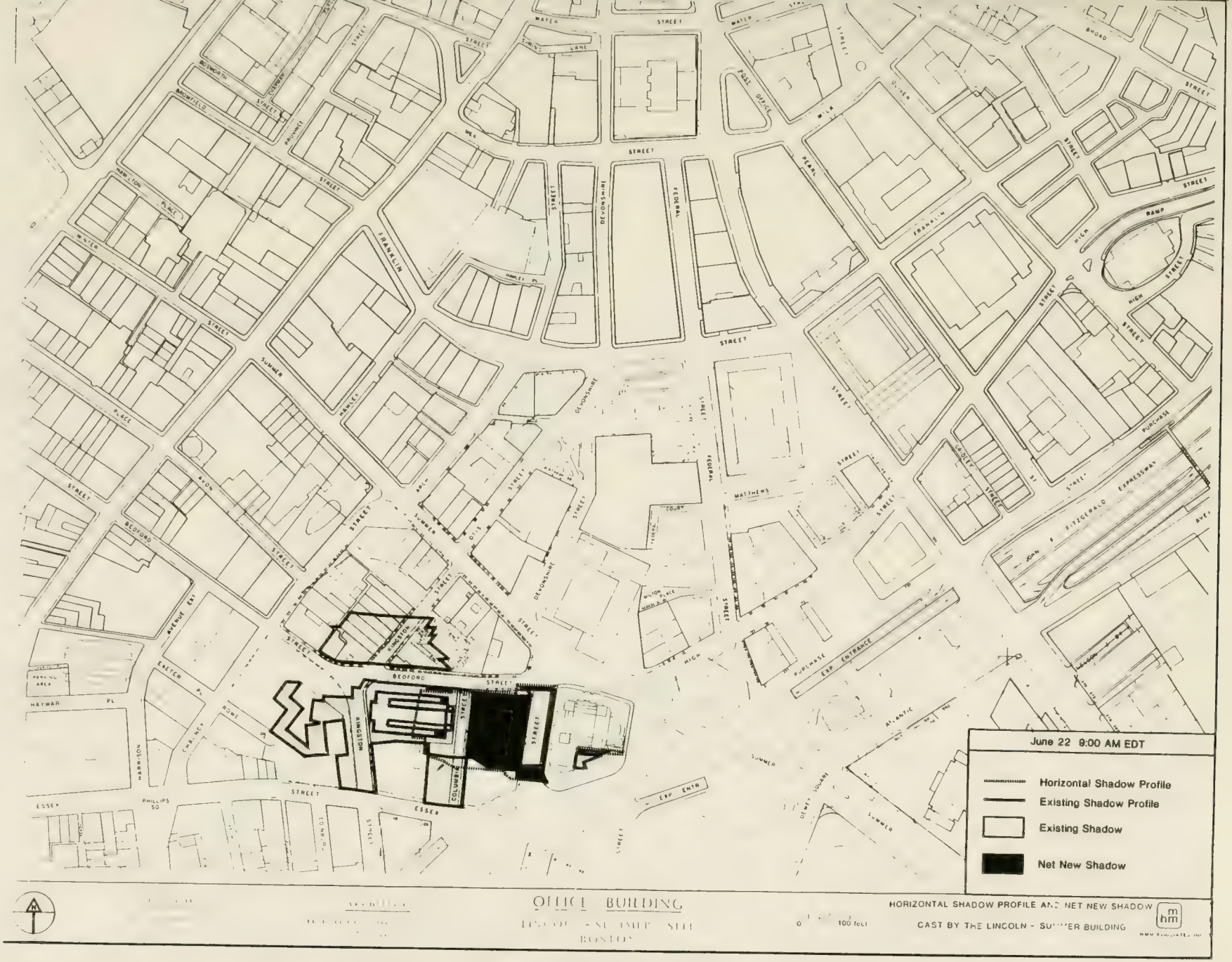


FIGURE 4.2-3 HORIZONTAL SHADOW PROFILE
JUNE 22 9:00 AM EDT

June 22 12:00 PM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
LINCOLN - SUMMER ST.
BOSTON
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUMMER BUILDING
0
100 feet
FRANKLIN
DEVONSHIRE
FEDERAL
PEARL
SUMMER
BEDFORD
HIGH
PURCHASE
ATLANTIC
EXP ENTRANCE
EXP ENTR
JOHN F. FITZGERALD EXPRESSWAY

FIGURE 4.2-5 HORIZONTAL SHADOW PROFILE
JUNE 22 3:00 PM EDT

FIGURE 4.2-8 HORIZONTAL SHADOW PROFILE

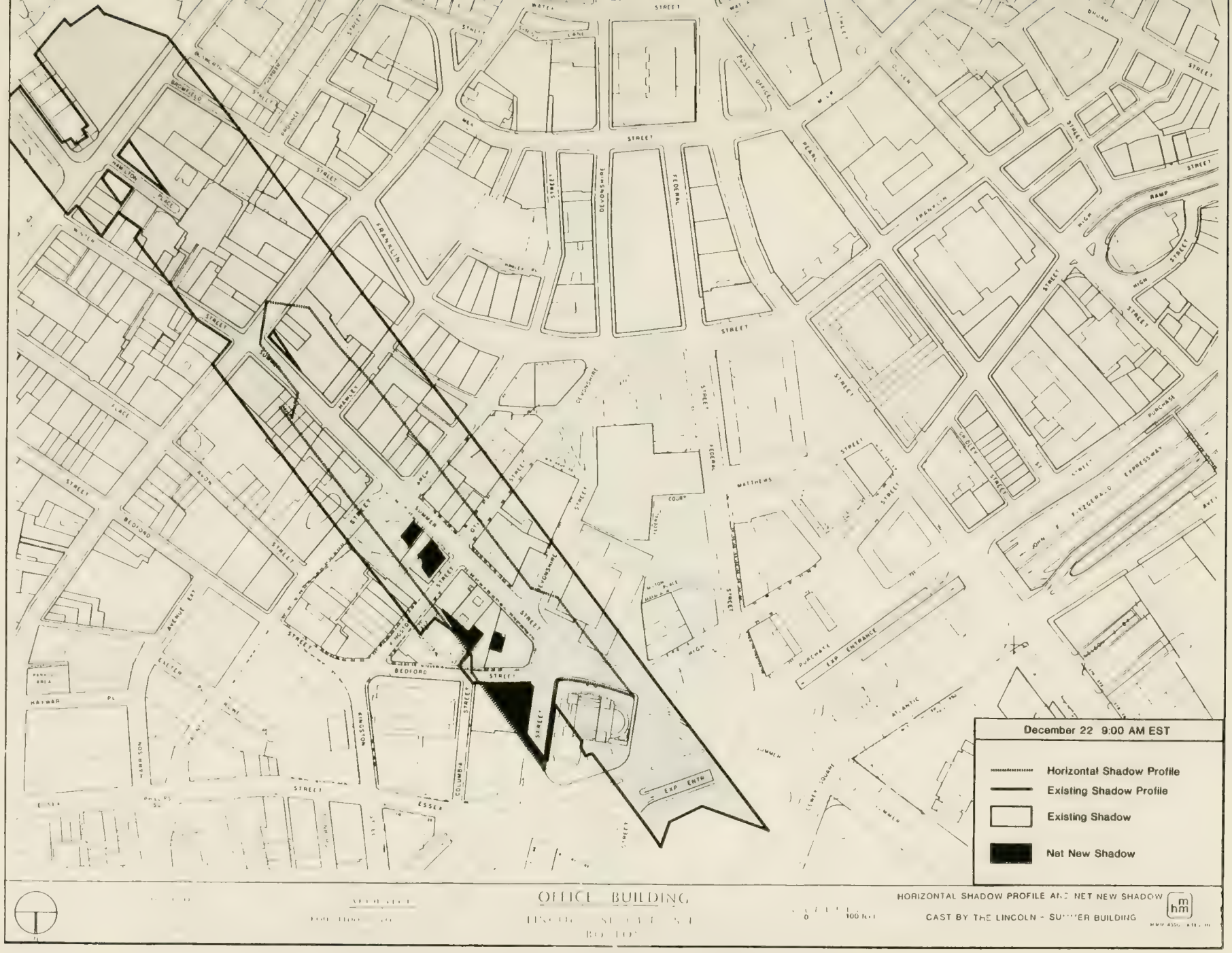
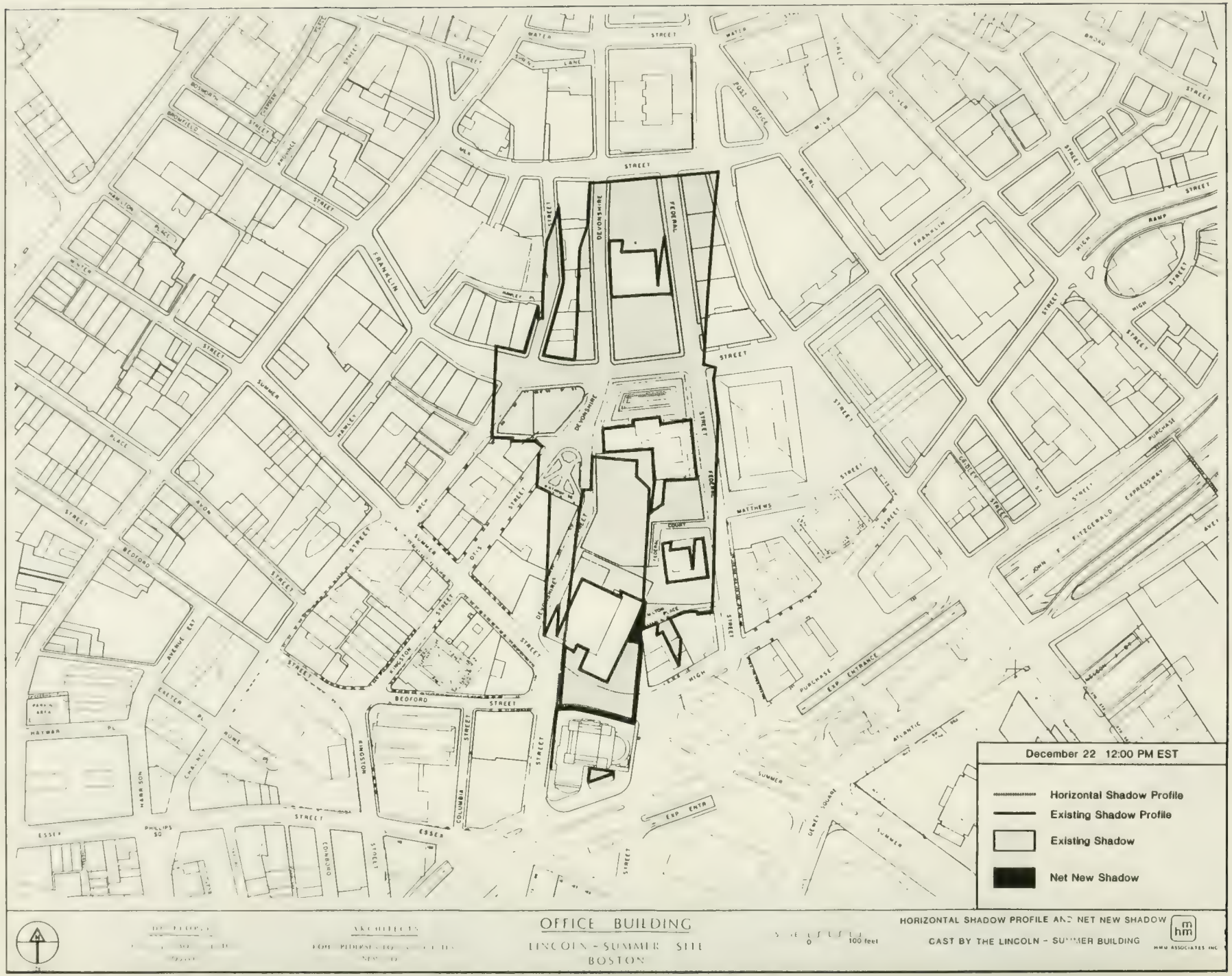

December 22 9:00 AM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUMMER BUILDING

FIGURE 4.2-9 HORIZONTAL SHADOW PROFILE
DECEMBER 22 9:00 AM EST


December 22 12:00 PM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
LINCOLN - SUMMER SITE
BOSTON
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUMMER BUILDING
0
100 feet
HMM ASSOCIATES INC

4.2-13

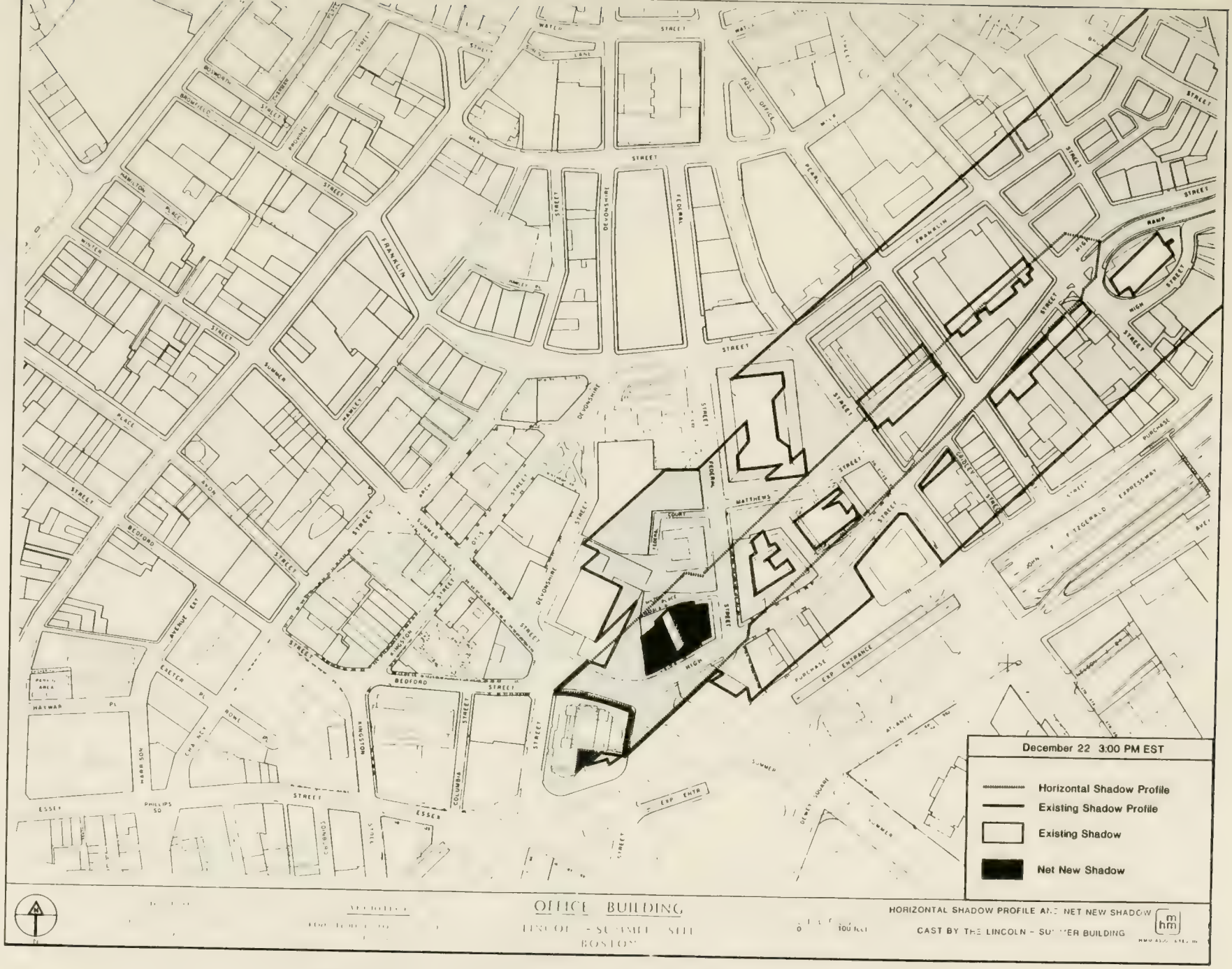
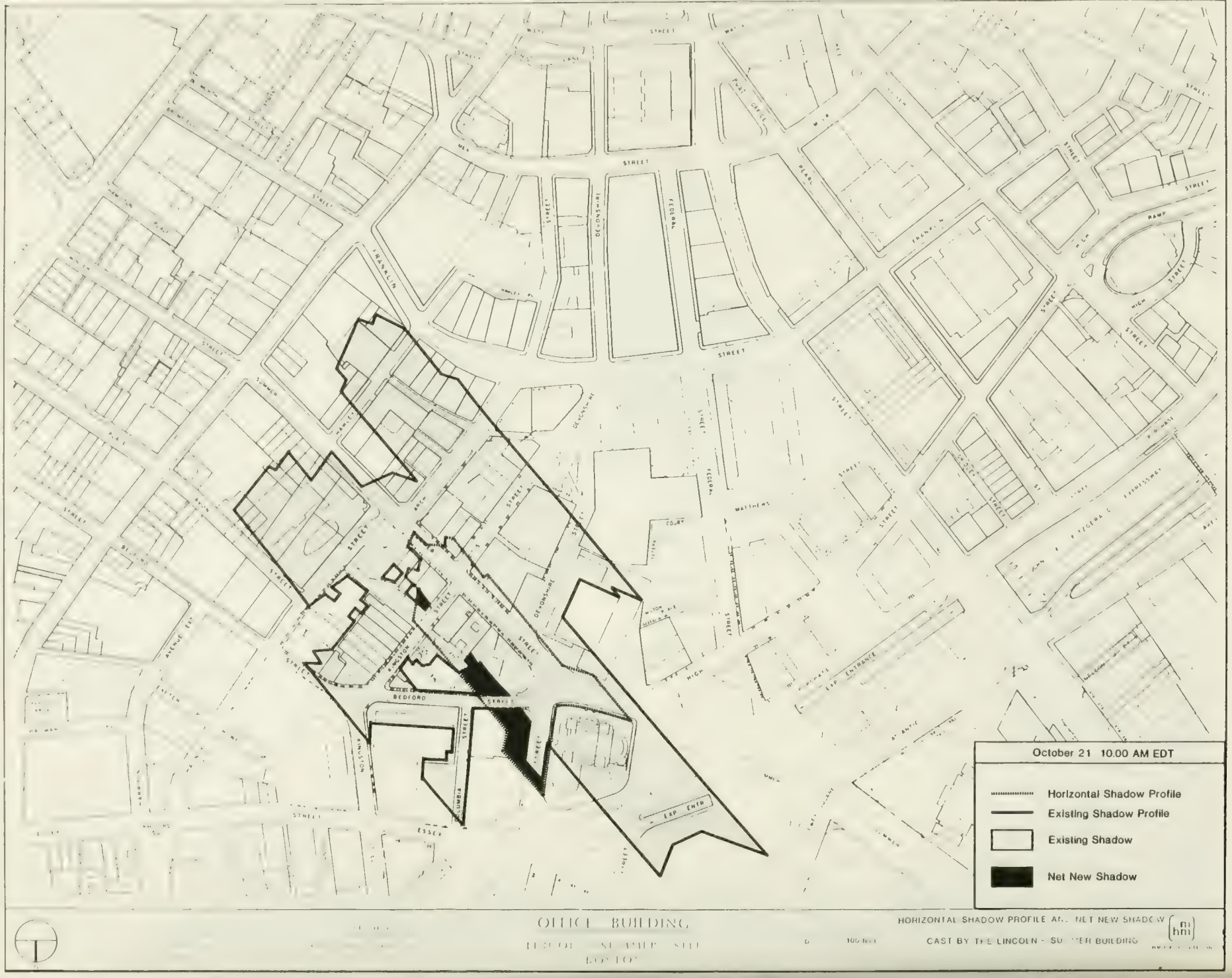


FIGURE 4.2-11 HORIZONTAL SHADOW PROFILE
DECEMBER 22 3:00 PM EST


October 21 10.00 AM EDT
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUMMER BUILDING

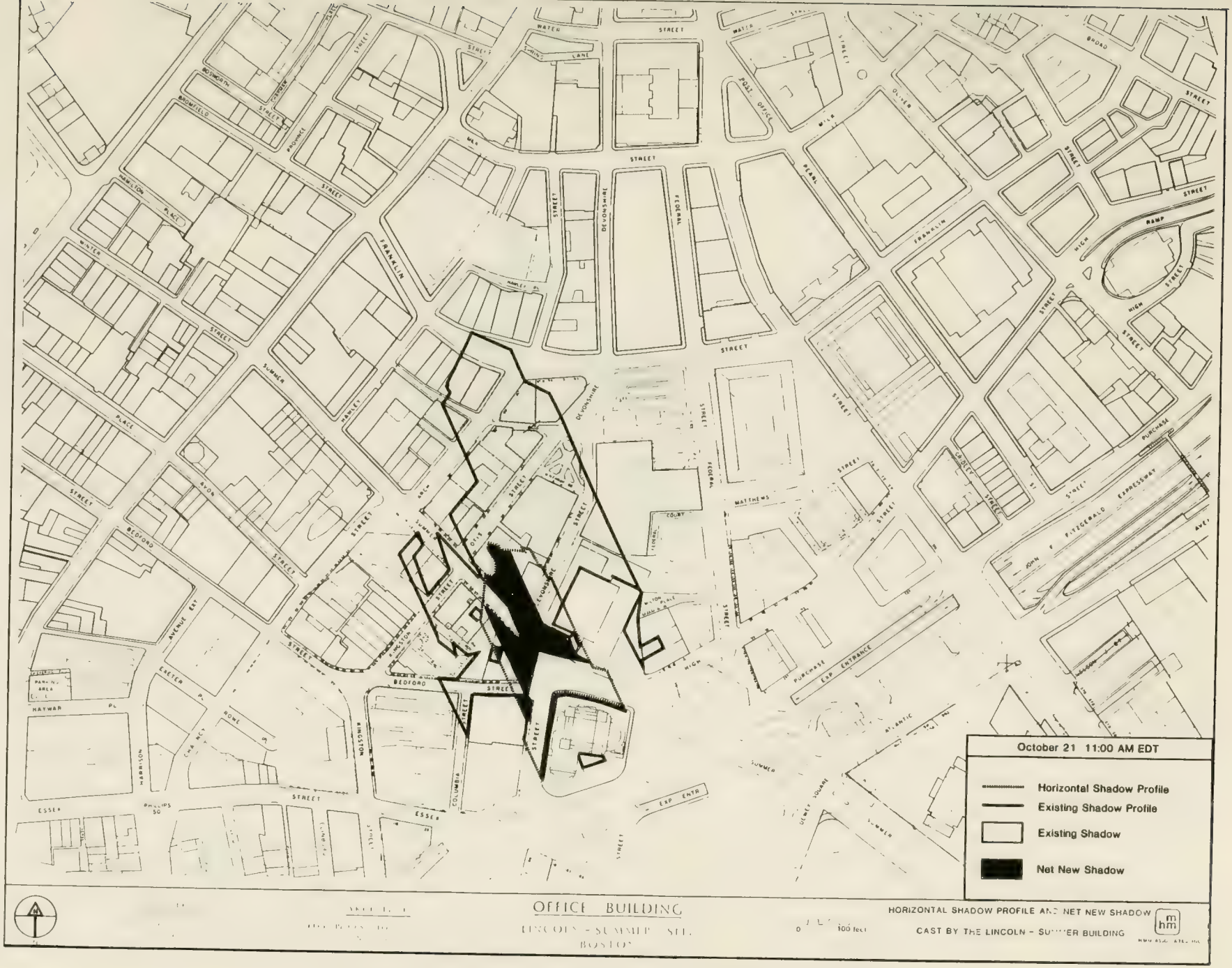


FIGURE 4.2-13 HORIZONTAL SHADOW PROFILE
OCTOBER 21 11:00 AM EDT

FIGURE 4.2-14 HORIZONTAL SHADOW PROFILE

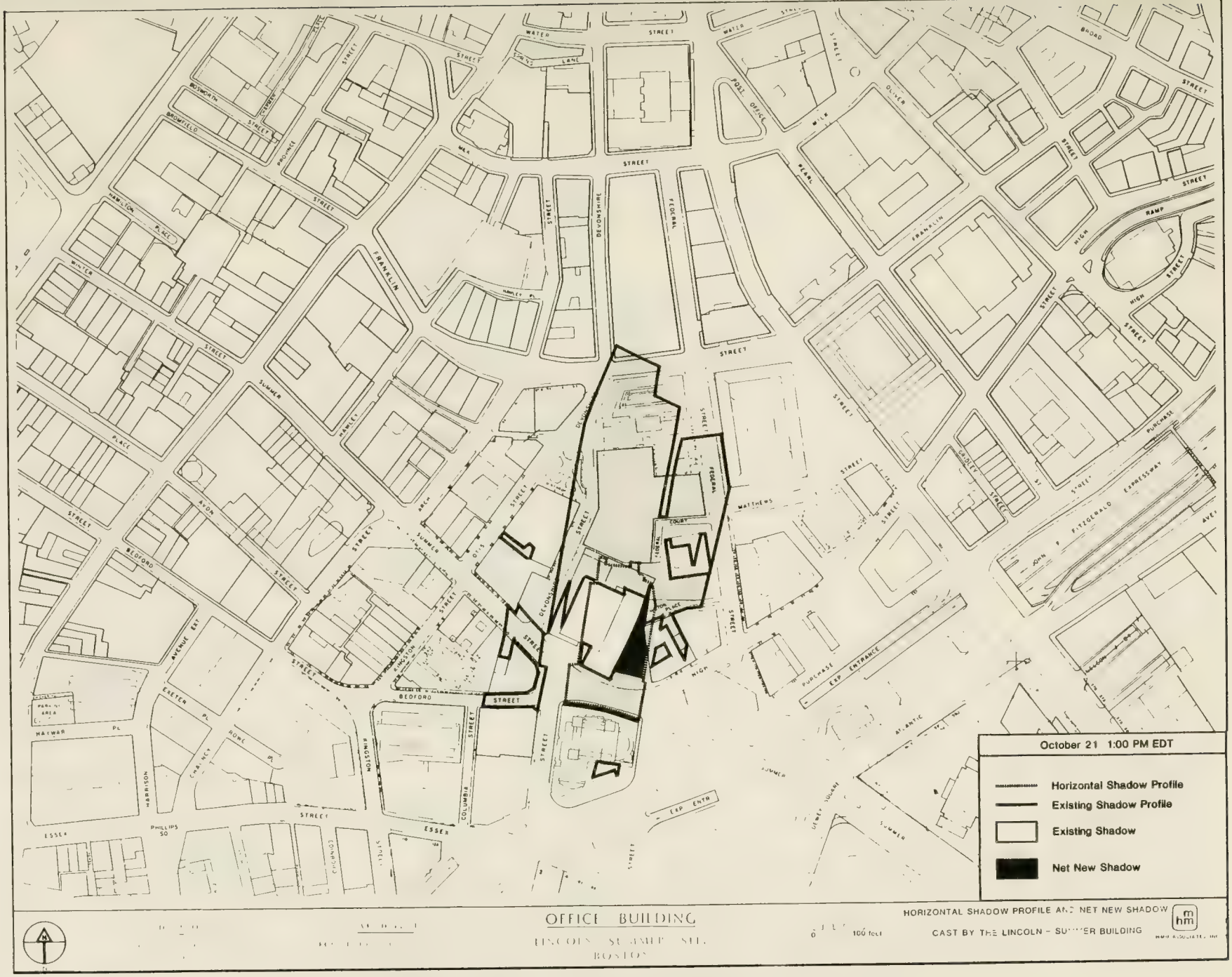


FIGURE 4.2-15 HORIZONTAL SHADOW PROFILE
OCTOBER 21 1:00 PM EDT

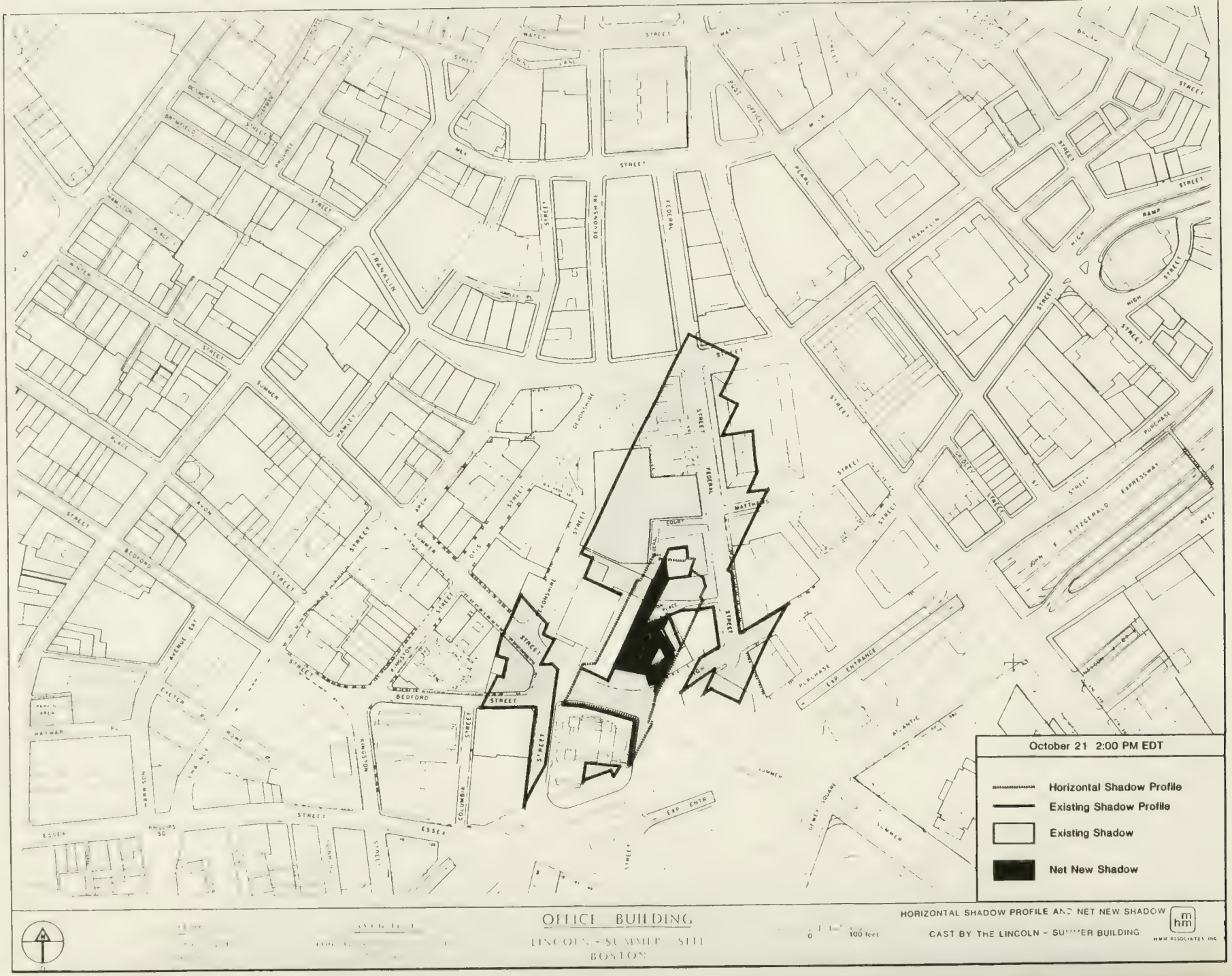


FIGURE 4.2-16 HORIZONTAL SHADOW PROFILE

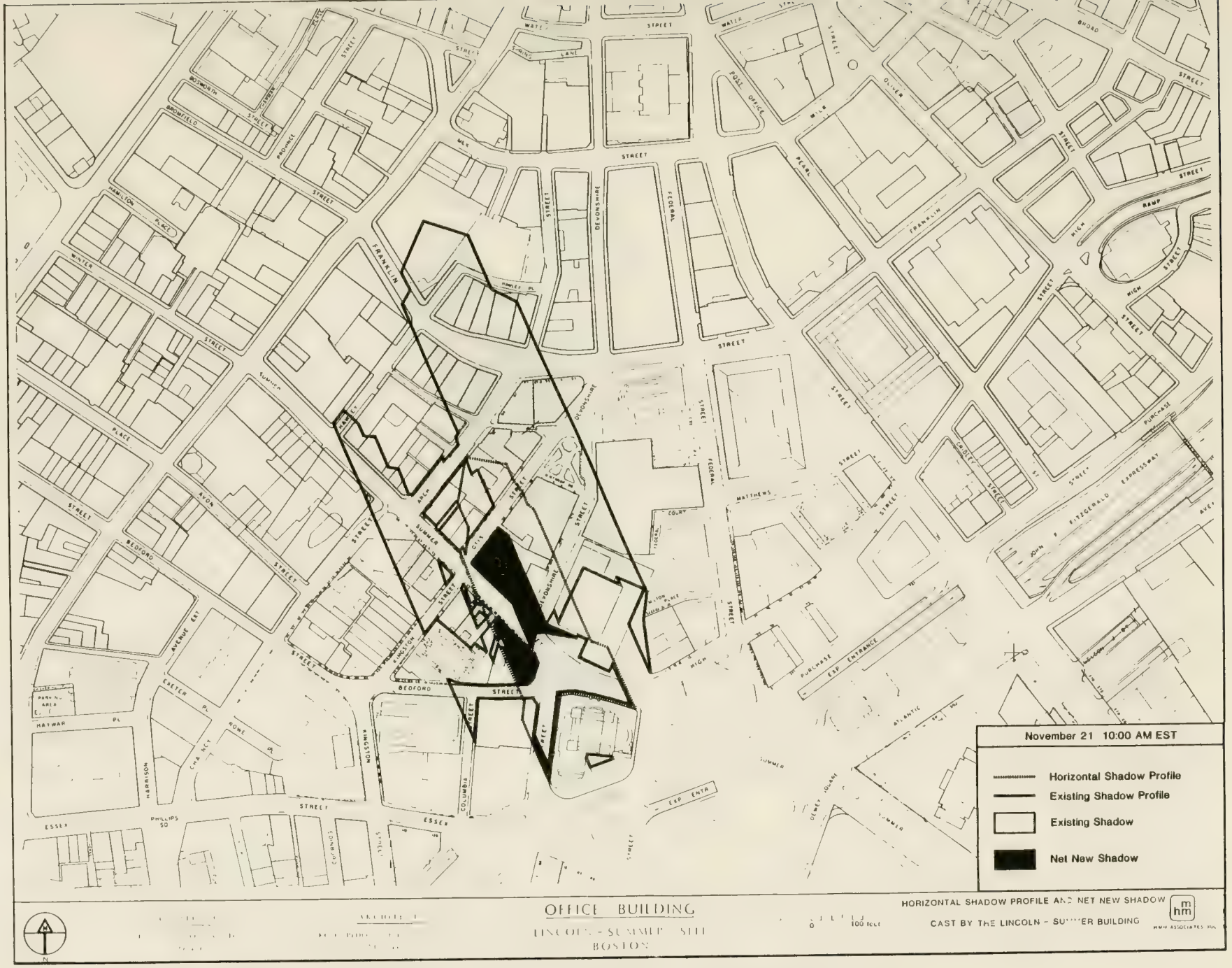


FIGURE 4.2-17 HORIZONTAL SHADOW PROFILE
NOVEMBER 21 10:00 AM EST

November 21 1:00 PM EST
Horizontal Shadow Profile
Existing Shadow Profile
Existing Shadow
Net New Shadow
OFFICE BUILDING
HORIZONTAL SHADOW PROFILE AND NET NEW SHADOW
CAST BY THE LINCOLN - SUTTER BUILDING

FIGURE 4.2-20 HORIZONTAL SHADOW PROFILE

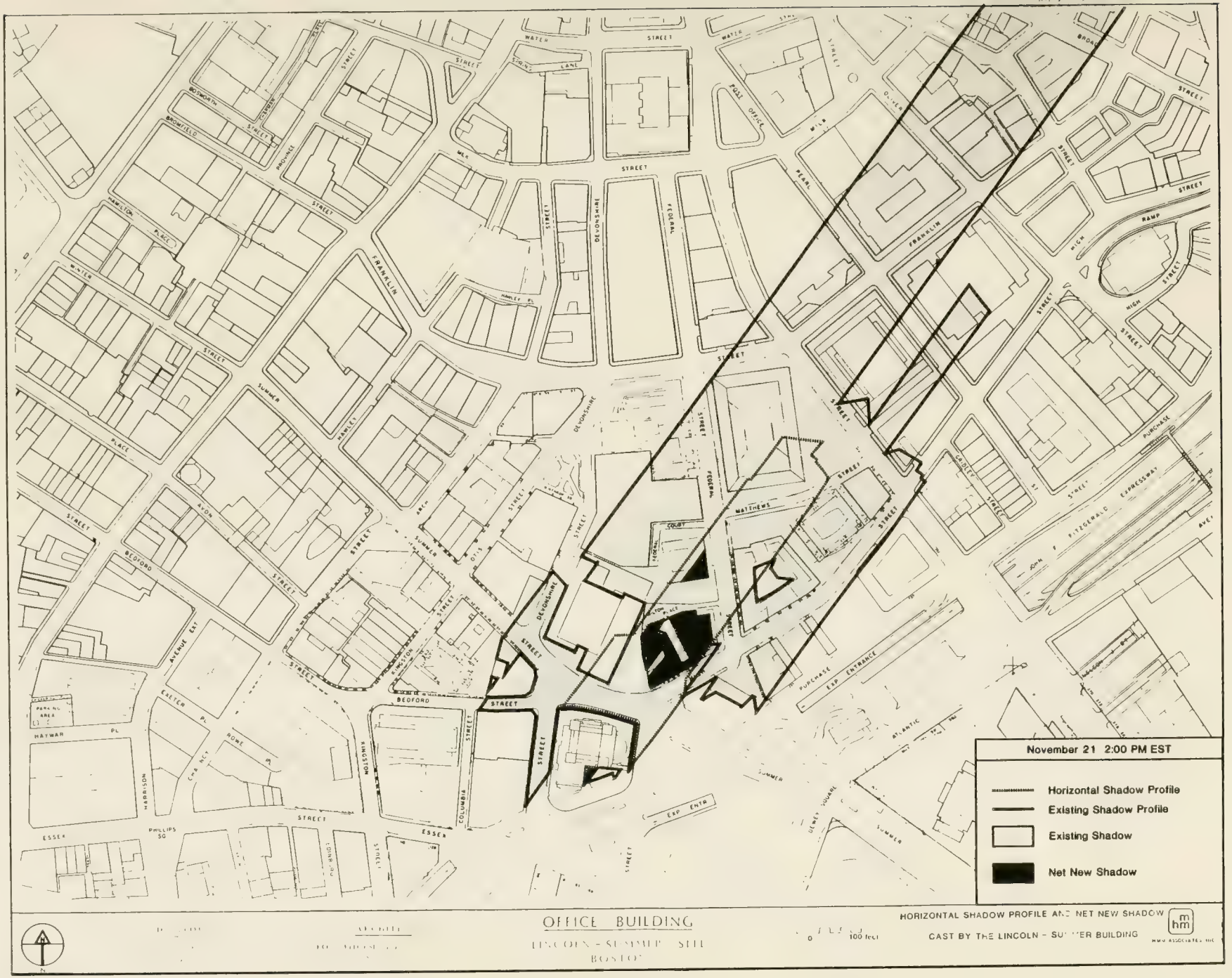


FIGURE 4.2-21 HORIZONTAL SHADOW PROFILE
NOVEMBER 21 2:00 PM EST

4.3 DAYLIGHT IMPACT

An analysis of the proposed 125 Summer Street Building was performed to determine the amount of available daylight at street level as a result of introduction of the project. Of interest is the proposed building's ability to preserve potential sunlight utilizing design features such as setbacks and notching of corners.

The daylight study for 125 Summer Street was developed incorporating the procedures recommended by the Boston Redevelopment Authority (BRA).* These procedures are based on a "fish eye" view of the project from ground level at the center of an adjacent city street. From this street level perspective, the methodology involves mapping the project's base, setbacks, corners, and other features to a base map (see Figure 4.3.1) using lateral and elevation angles. These angles are easily calculated using tier heights, distances from the street level reference point, and the arc tangent trigonometric function. Lateral elevations in this study for both the proposed and existing configurations were determined using a protractor and scaled base maps (see Figures 4.3.2 and 4.3.3). Figure 4.3.3 presents the various tiers of the existing project site. Figures 4.3.4 through 4.3.7 show the four standard elevation views of the proposed project. These elevations were used to map the proposed configuration. The circled numbers on these figures are labels representing the various tiers of the project studied. These labels are used to reference each tier in Tables 4.3.1 through 4.3.4, which provide the elevation and lateral angles for the north, east, south and west elevations of the proposed project. Tables 4.3.5 through 4.3.8 provide data from each vantage point under the existing configuration. For each of these elevations "fish eye" views of the existing and proposed configurations were plotted. These are presented in Figures 4.3.8 through 4.3.15.

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* Personal communication, Mr. Skip Doty, BRA, Boston, MA, March 14, 1986.

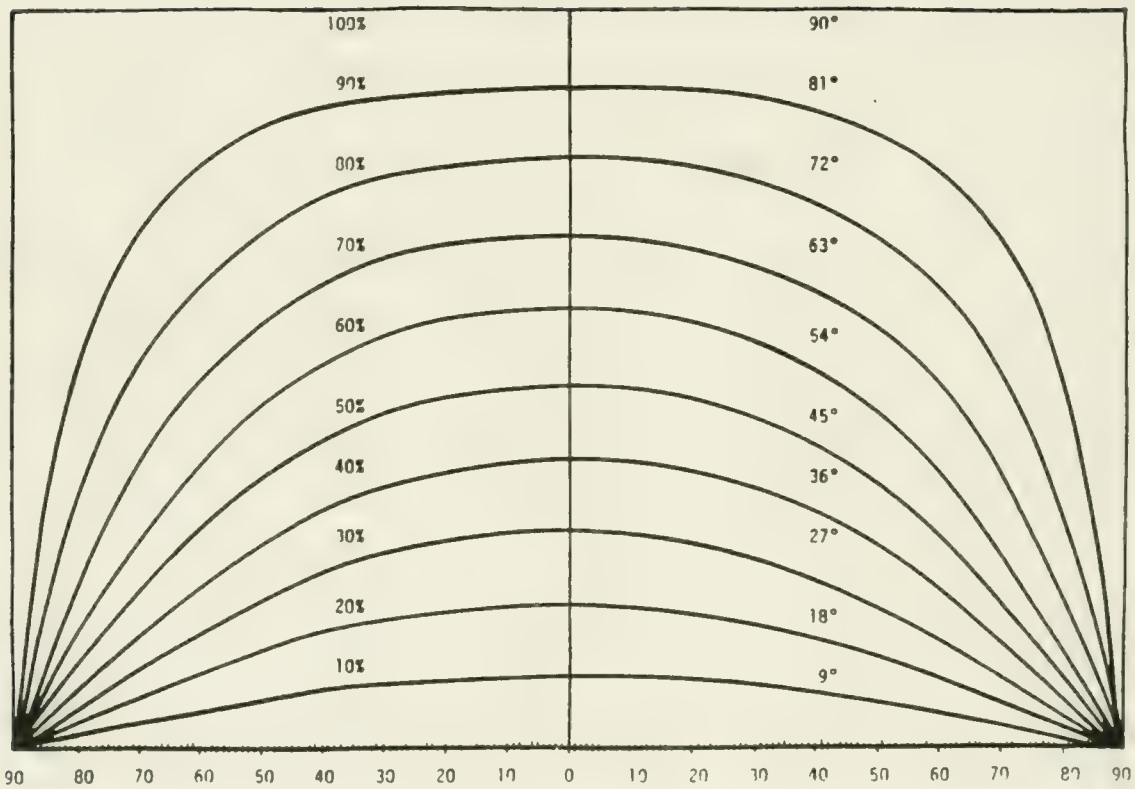

FIGURE 4.3.1 - "FISH EYE" BASE MAP

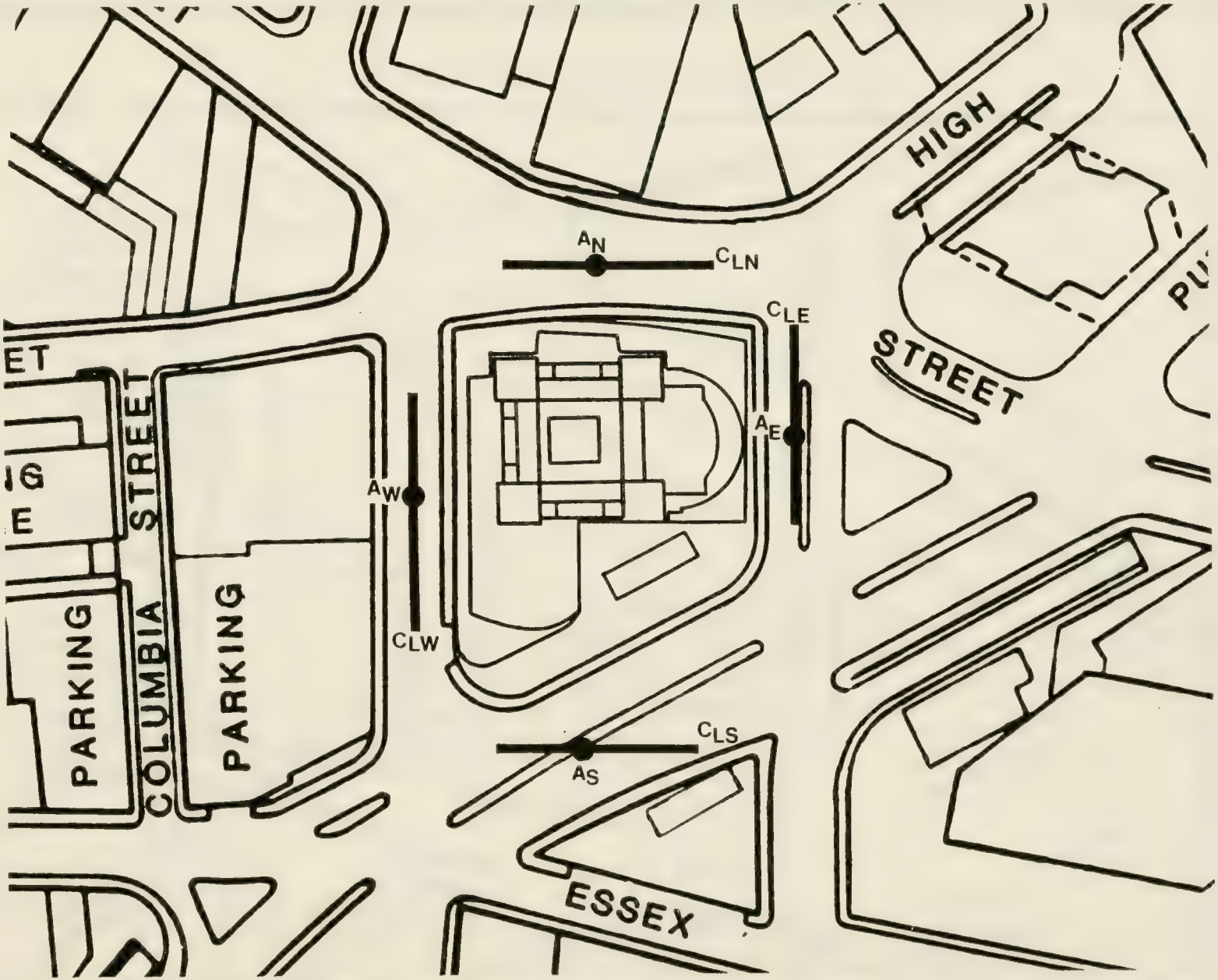

FIGURE 4.3.2 - PROPOSED PROJECT SITE

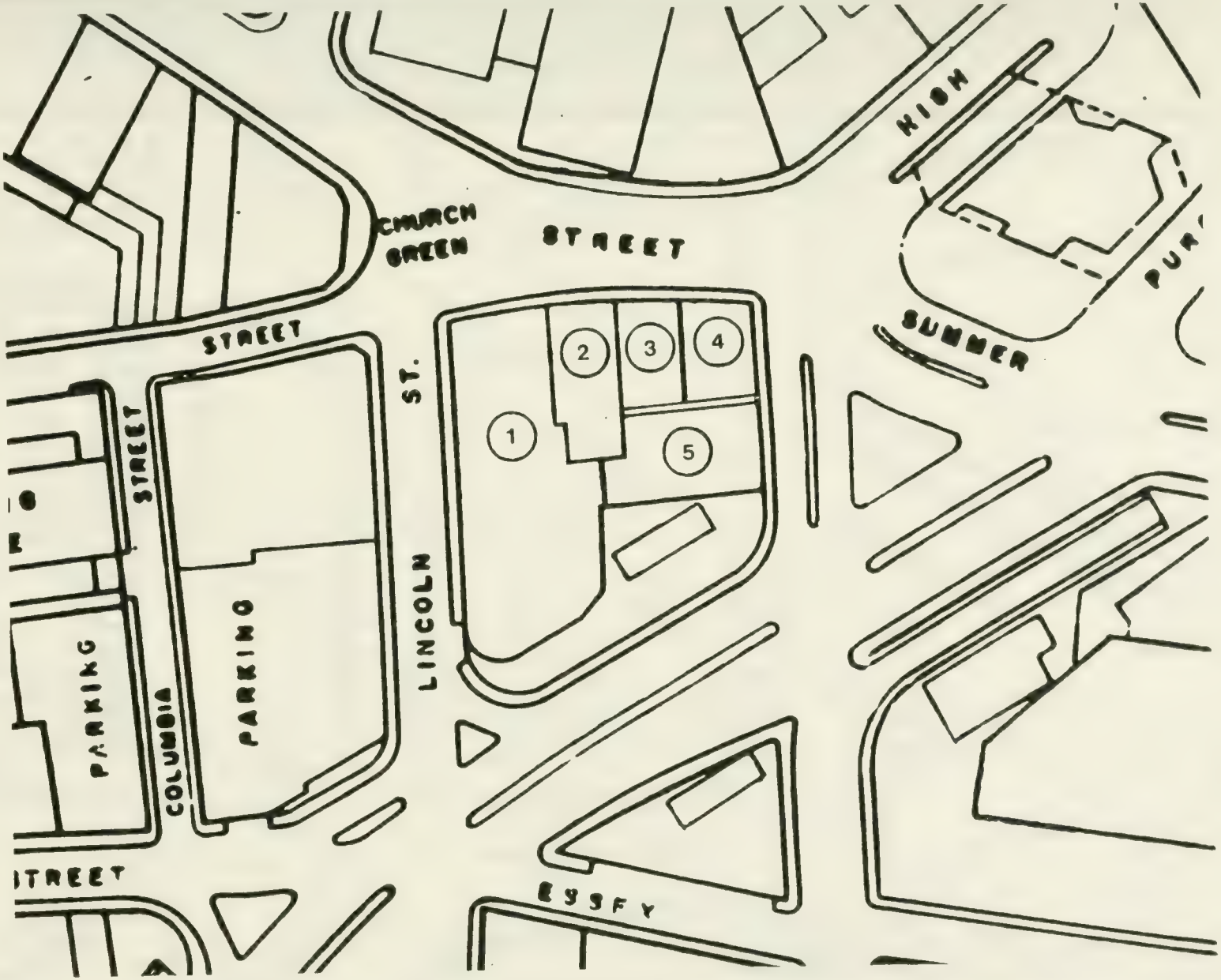

FIGURE 4.3.3 - EXISTING PROJECT SITE

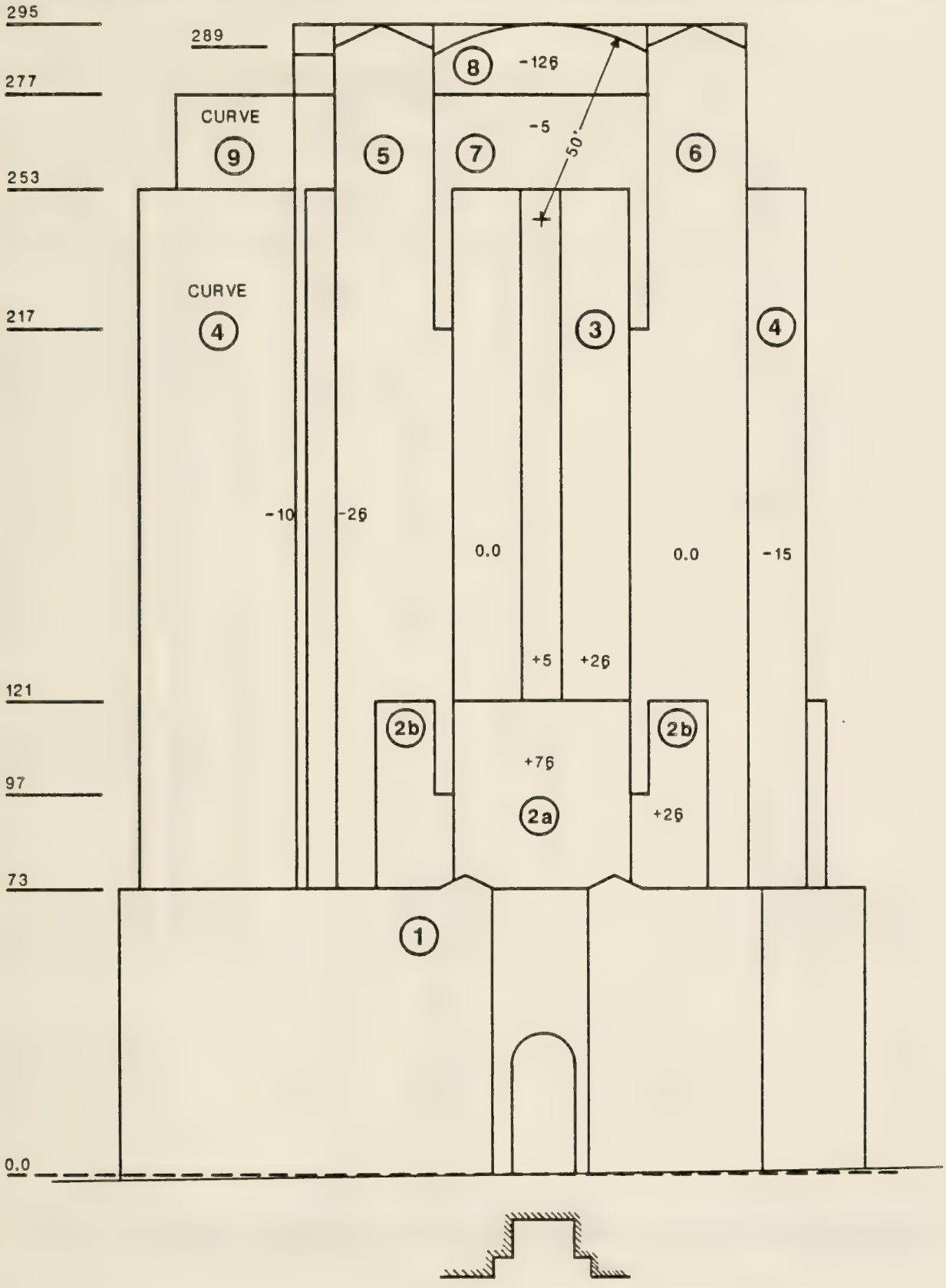

FIGURE 4.3.4 - NORTH ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

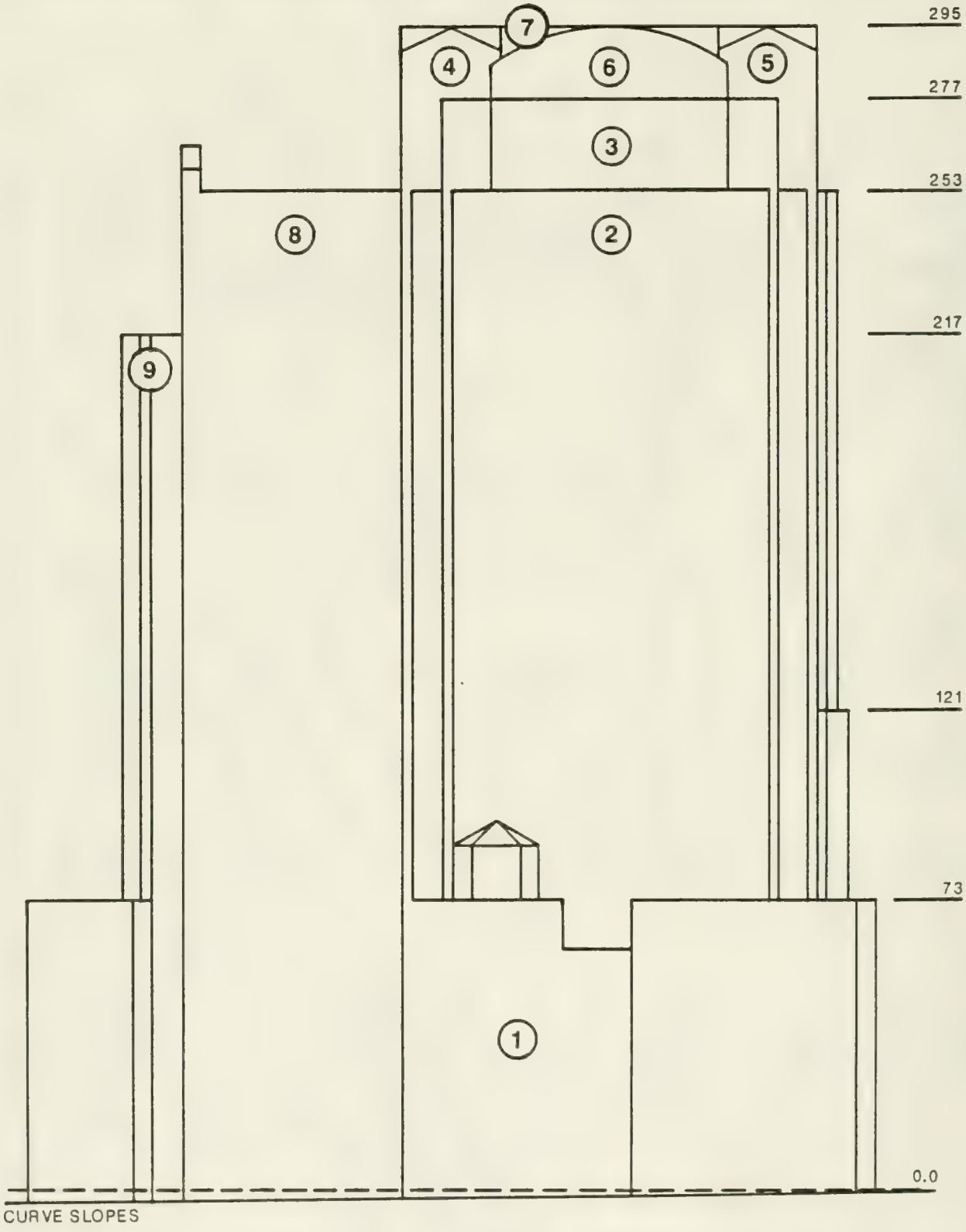

FIGURE 4.3.5 - EAST ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

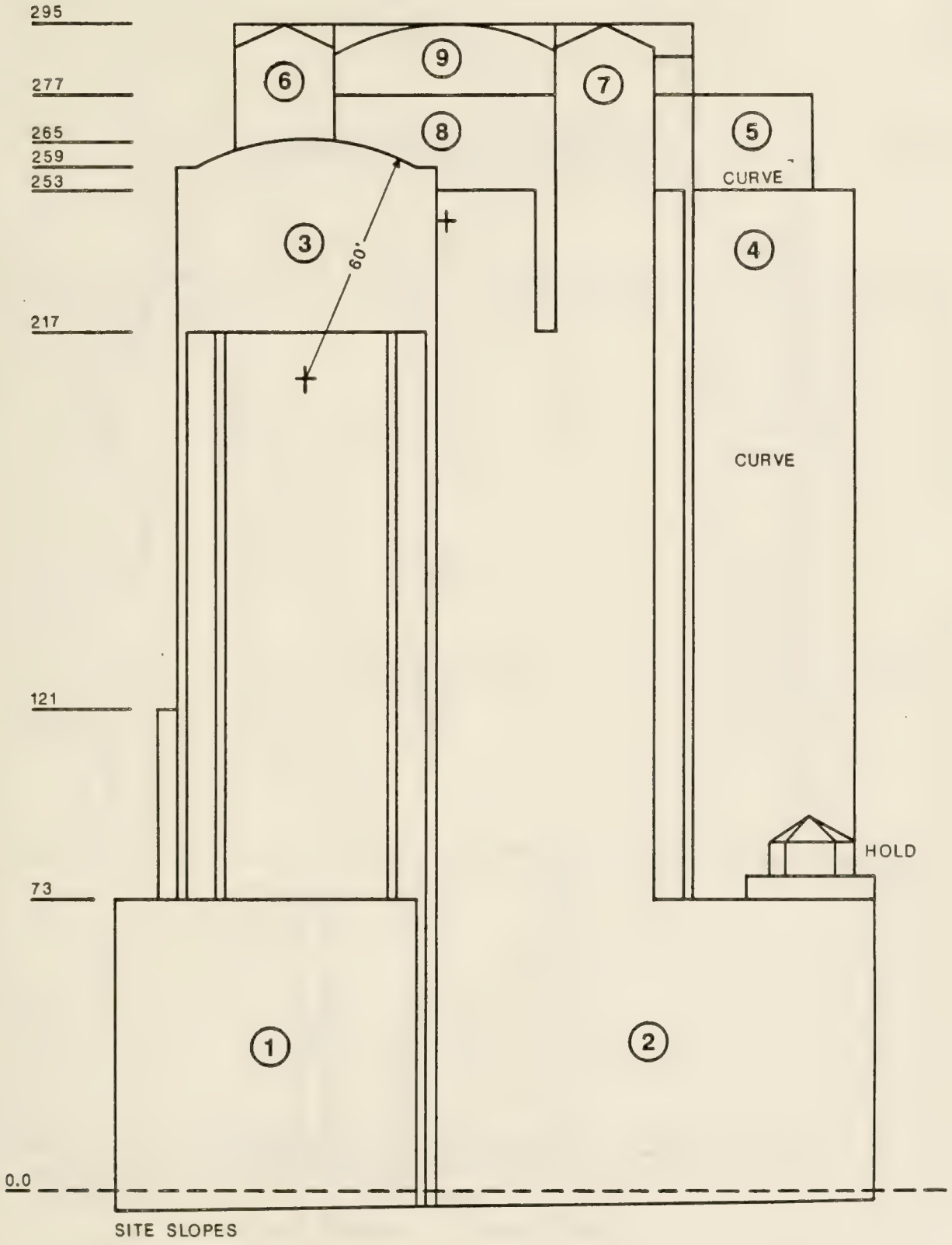

FIGURE 4.3.6 - SOUTH ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

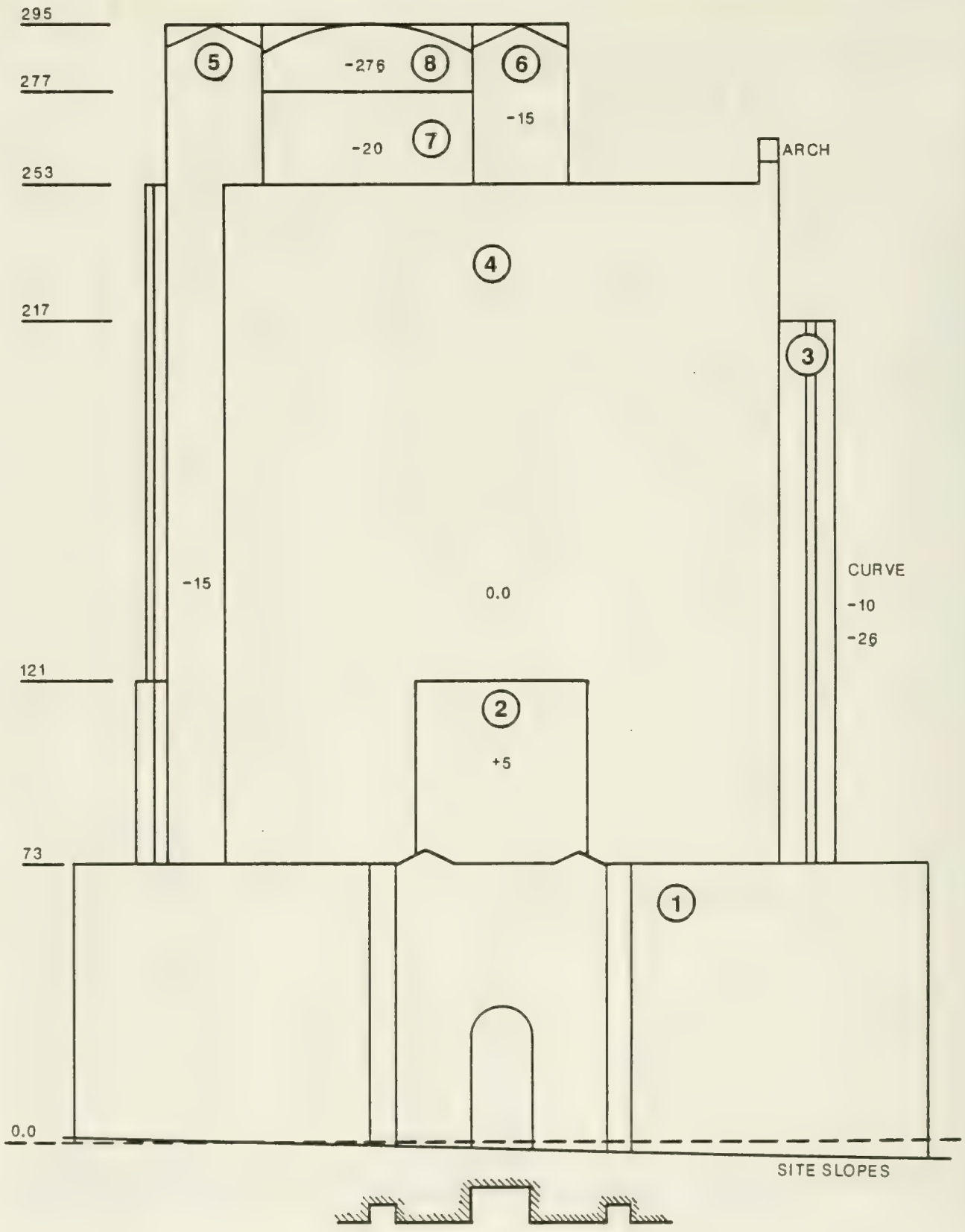

FIGURE 4.3.7 - WEST ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

TABLE 4.3.1

DAYLIGHT STUDY LOCATIONS
125 SUMMER STREET - NORTH ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
1	35	73	64	64 - (-64)
2a	55	121	66	10 - (-31)
2b	60	121	64	27 - (-42)
3	60	253	77	10 - (-31)
4	77.5	253	73	41 - (-46)
5	62.5	295	78	33 - (13)
6	62.5	295	78	-30 - (-46)
7	67.5	277	76	13 - (-30)
8	75	295	76	12 - (-27)
9	87.5	277	72	36 - 32
Site Edge	NA	NA	NA	64 - (-64)

* Lot Length = 190 feet
  1/2 Lot = 95 feet

** See Figure D.4

*** Angles are determined with respect to a line drawn perpendicular to line C_{LN} through point A_N (see Figure D.2).

TABLE 4.3.2

DAYLIGHT STUDY PARAMETERS
125 SUMMER STREET - EAST ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
1	39	73	62	50 - (-56)
2	85-44-85	253	71-80-71	28 - 0 - (-28)
3	83-54-83	277	73-79-73	20 - 0 - (-20)
4	94	284	72	27 - 13
5	94	284	72	-13 - (-27)
6	84	295	74	17 - (-17)
7	119	295	68	18 - (-18)
8	148	253	60	34 - 19
9	152	217	55	36 - 34
Site Edge	NA	NA	NA	50 - (-56)

* Lot Length = 120 feet
  1/2 Lot = 60 feet

** See Figure D.5

*** Angles are determined with respect to a line drawn perpendicular to line C_{LE} through point A_E (see Figure D.2).

TABLE 4.3.3

DAYLIGHT STUDY PARAMETERS
125 SUMMER STREET - SOUTH ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
1	47-72	73	57-45	57 - 8
2	138	73	28	3 - (-36)
3	83	259	72	39 - 5
4	141-188	253	61-53	-20 - (-28)
5	148-188	277	62-56	-21 - (-26)
6	137	295	65	20 - 11
7	137	295	65	-11 - (-20)
8	143	277	63	11 - (-11)
9	150	295	63	10 - (-10)
Site Edge	NA	NA	NA	57 - 51

* Lot Length = 192 feet
1/2 Lot = 96 feet

** See Figure D.6

*** Angles are determined with respect to a line drawn perpendicular to line C_{LS} through point A_S (see Figure D.2).

TABLE 4.3.4

DAYLIGHT STUDY PARAMETERS

125 SUMMER STREET - WEST ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
1	27	73	70	+74 - (-74)
2	37	123	73	+28 - (-28)
3	45	217	78	-57 - (-60)
4	42	253	81	58 - (-57)
5	57	295	79	55 - 39
6	57	295	79	5 - (-16)
7	62	277	77	44 - 5
8	70	295	77	41 - 5
Site Edge	NA	NA	NA	+74 - (-74)

---

* Lot Length = 240 feet
1/2 Lot = 120 feet

** See Figure D.7

*** Angles are determined with respect to a line drawn perpendicular to line C_{LW} through point A_W (see Figure D.2).

TABLE 4.3.5

DAYLIGHT STUDY PARAMETERS

EXISTING BUILDINGS - NORTH ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
1	35	73	64	(-48) - (-64)
2	35	36	46	15 - (-48)
3	35	56	58	48 - 15
4	35	73	64	64 - 48
5	105	66	32	
Proposed Site Edge	NA	NA	NA	64 - (-64)

* Lot Length = 190 feet
  1/2 Lot = 95 feet

** See Figure D.3

*** Angles are determined with respect to a line drawn perpendicular to line C_{LN} through point A_N (see Figure D.2).

TABLE 4.3.6

DAYLIGHT STUDY PARAMETERS
EXISTING BUILDING - EAST ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
4	39	73	62	50 - (-6)
5	39	66	59	(-6) - (-31)
Proposed Site Edge	NA	NA	NA	50 - (-46)

* Lot Length = 120 feet
1/2 Lot = 60 feet

** See Figure D.3

*** Angles are determined with respect to a line drawn perpendicular to line C_{LE} through point A_E (see Figure D.2).

TABLE 4.3.7

DAYLIGHT STUDY PARAMETERS
EXISTING BUILDING - SOUTH ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
1	83	73	41	46 - 3
5	138	66	26	3 - (-36)
Proposed Site Edge	NA	NA	NA	57 - (-36)

* Lot Length = 192 feet
1/2 Lot = 96 feet

** See Figure D.3

*** Angles are determined with respect to a line drawn perpendicular to line C_{LS} through point A_S (see Figure D.2).

TABLE 4.3.8

DAYLIGHT STUDY PARAMETERS
EXISTING BUILDING - WEST ELEVATION*

Tier #**	Distance From Center of Street (feet)	Height (feet)	Elevation Angle (deg)	Lateral Angles*** (deg)
1	27	73	70	+74 - (-70)
Proposed Site Edge	NA	NA	NA	+74 - (-74)

* Lot Length = 240 feet
1/2 Lot = 120 feet

** See Figure D.3

*** Angles are determined with respect to a line drawn perpendicular to line C_{LW} through point A_W (see Figure D.2).

Percent available daylight for both the build and no-build configurations are provided in Table 4.3.9. The existing available daylight percentages are based on the lot size of the proposed project.

North Elevation.

Figure 4.3.9 presents a "fish eye" view of the project from location A_N (see Figure 4.3.2) on Summer Street. This diagram demonstrates that the project's wide base, which is 73 feet tall, and the 295 foot tower to be the predominant features. Results of the analysis demonstrated that 82% of available daylight to be blocked out by the proposed project as opposed to 61% under the existing configuration (see Figure 4.3.10).

East Elevation.

The "fish eye" view of the project's east elevation from South Street (see location A_E on Figure 4.3.2) is diagrammed in Figure 4.3.11. The view is almost symmetrical about the base of the project and the project's half cylindrical section (253 feet high) along the east side of the proposed tower. Figure 4.3.12 presents a similar "fish eye" view of the existing configuration. The results indicate 78% of available daylight blocked by the proposed project while 68.5% is blocked by existing buildings.

South Elevation.

The south elevation views, shown in Figures 4.3.13 and 4.3.14 are based on mappings of the proposed and existing buildings, respectively, from an observation point on the Surface Artery, at location A_S in Figure 4.3.2. Due to the project's "L" shape this "fish eye" view appears

TABLE 4.3.9

PERCENT DAYLIGHT BLOCKED

Elevation	Street	Percent Daylight Blocked		
		Proposed Project	Existing Buildings	Difference
North	Summer	82.0	61.0	21.0
East	South	78.0	68.5	9.5
South	Surface Artery	69.5	34.0	35.5
West	Lincoln	87.5	76.0	11.5

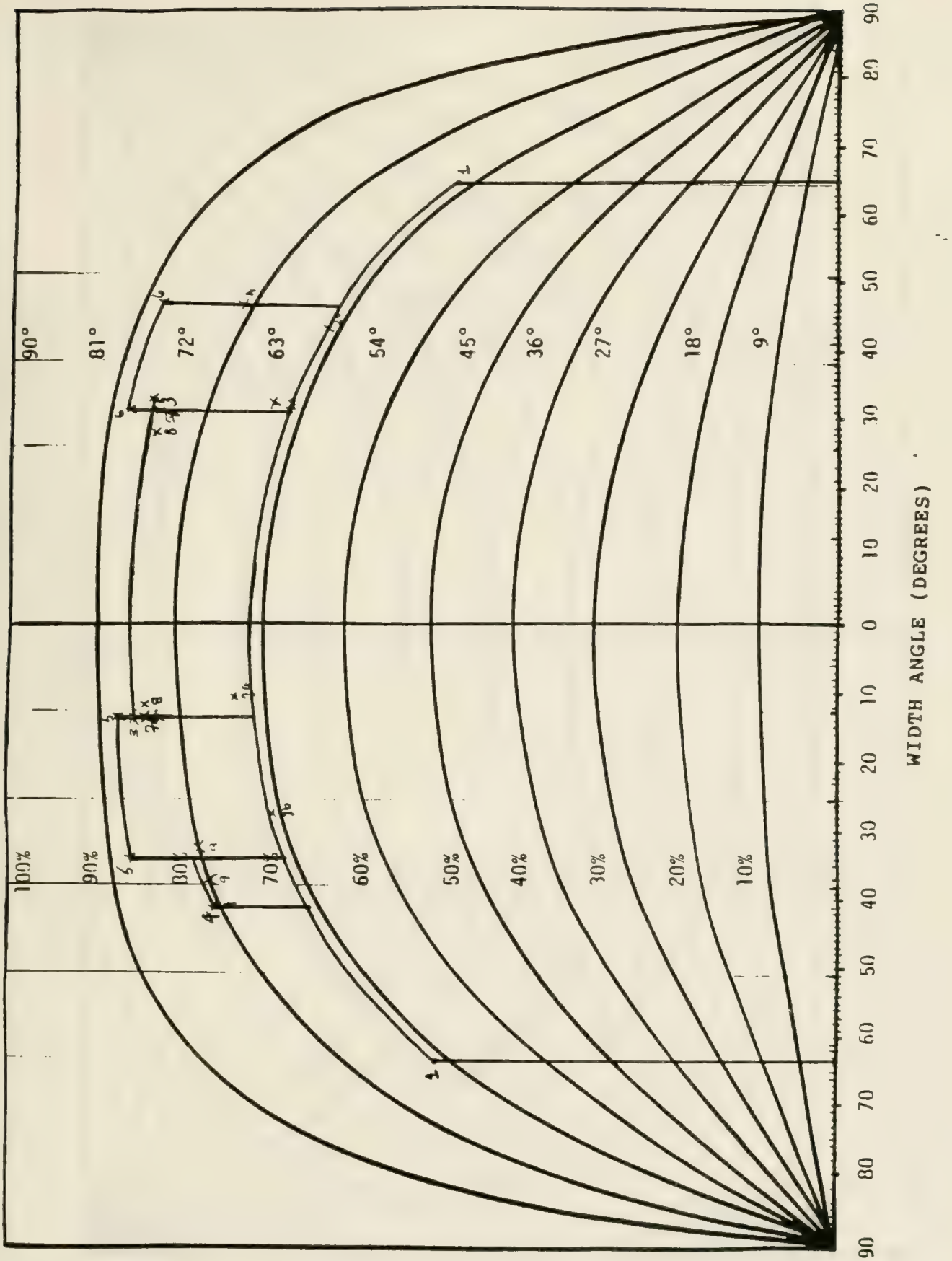

FIGURE 4.3.8 - 125 SUMMER STREET - NORTH ELEVATION

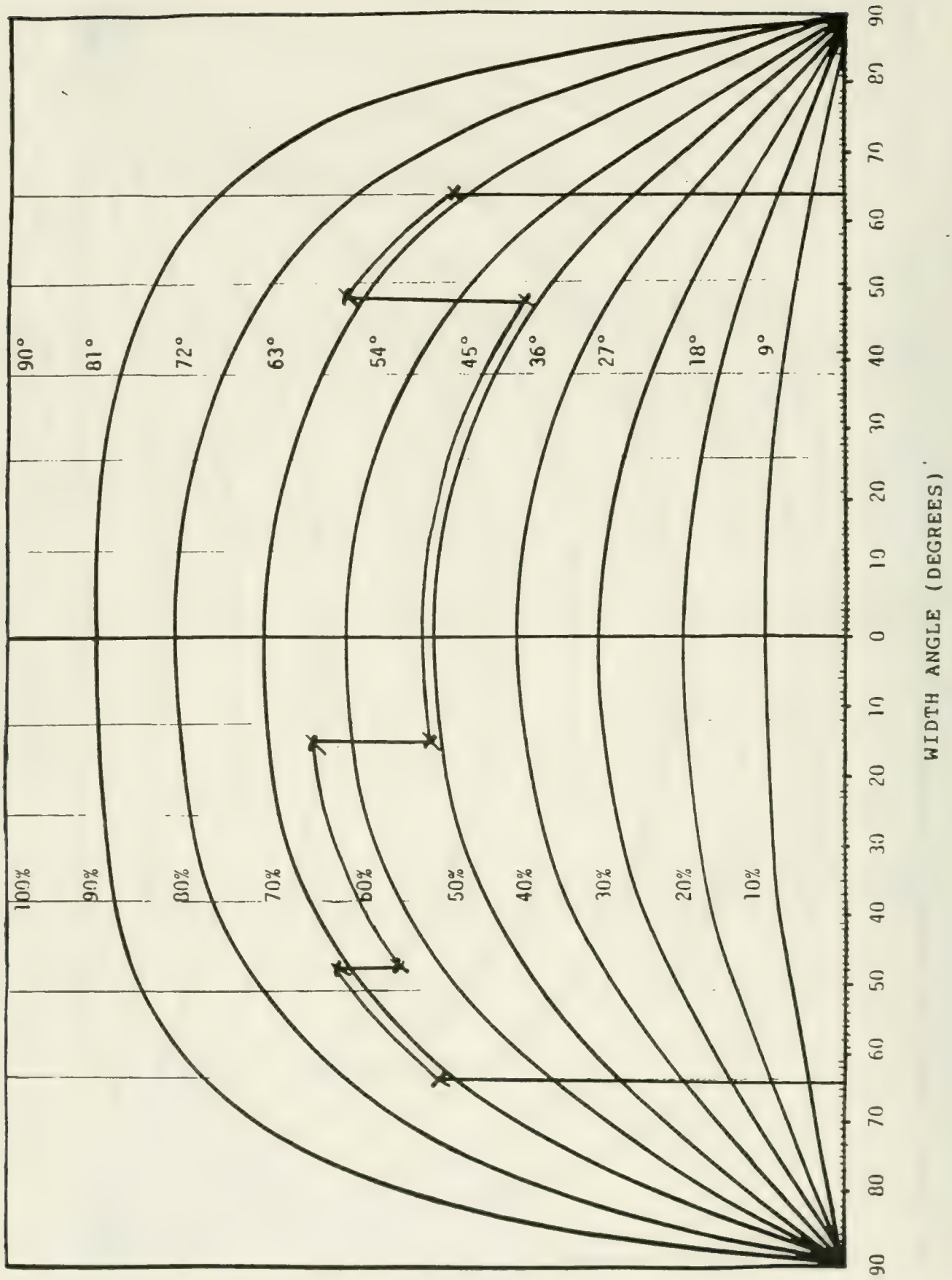

FIGURE 4.3.9 - EXISTING BUILDINGS - NORTH ELEVATION

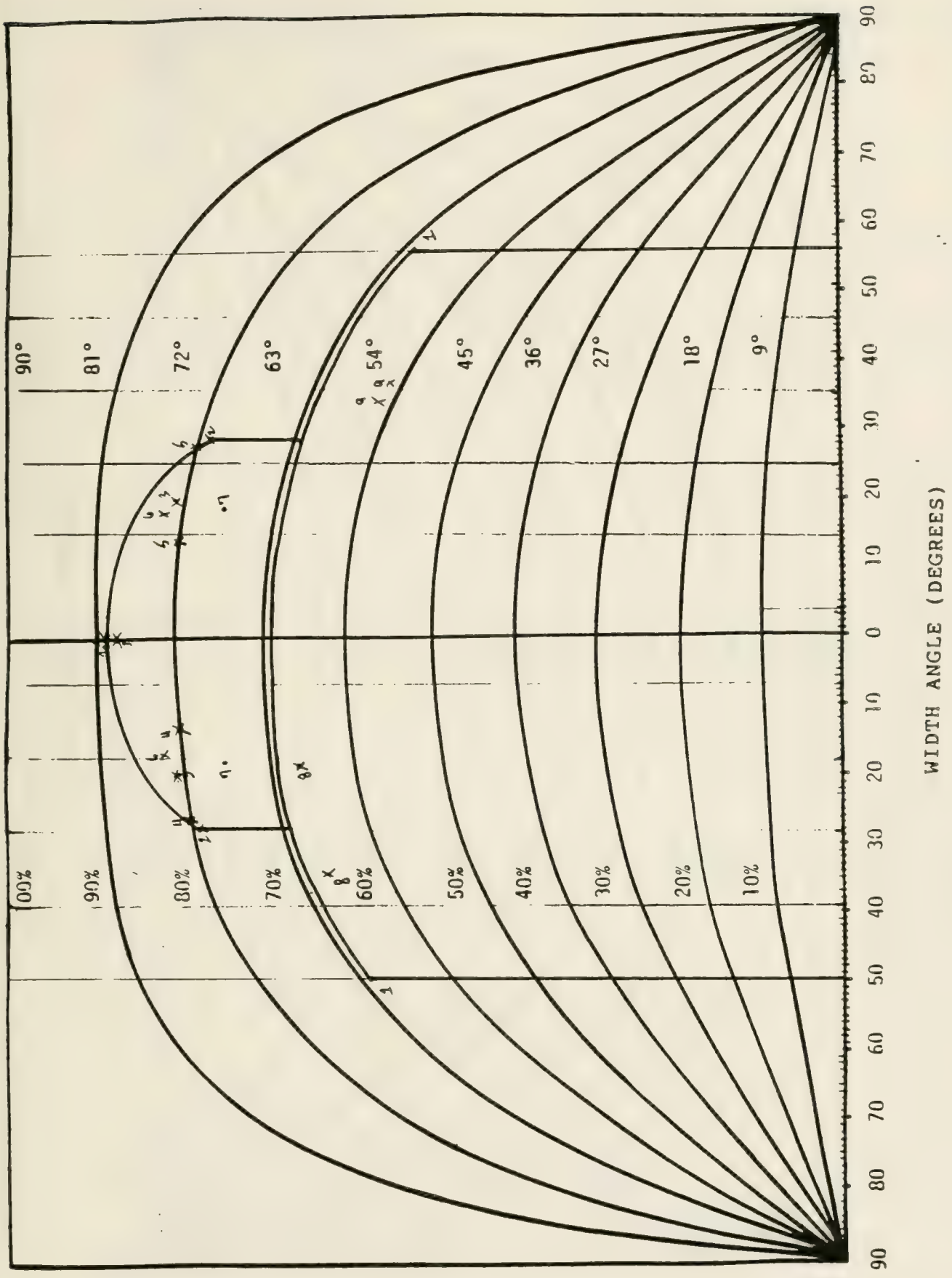

FIGURE 4.3.10 - 125 SUMMER STREET - EAST ELEVATION

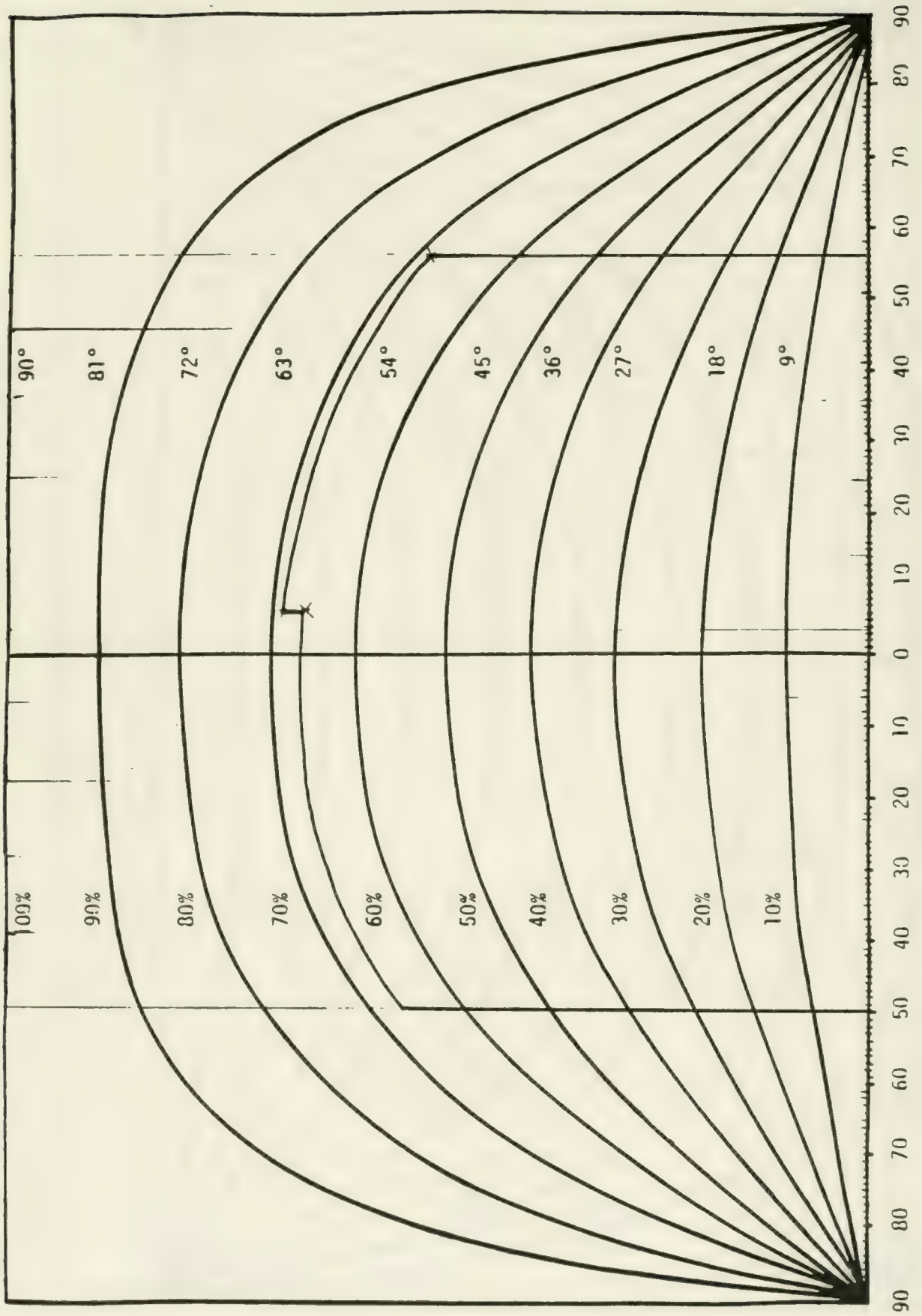

FIGURE 4.3.11 - EXISTING BUILDINGS - EAST ELEVATION

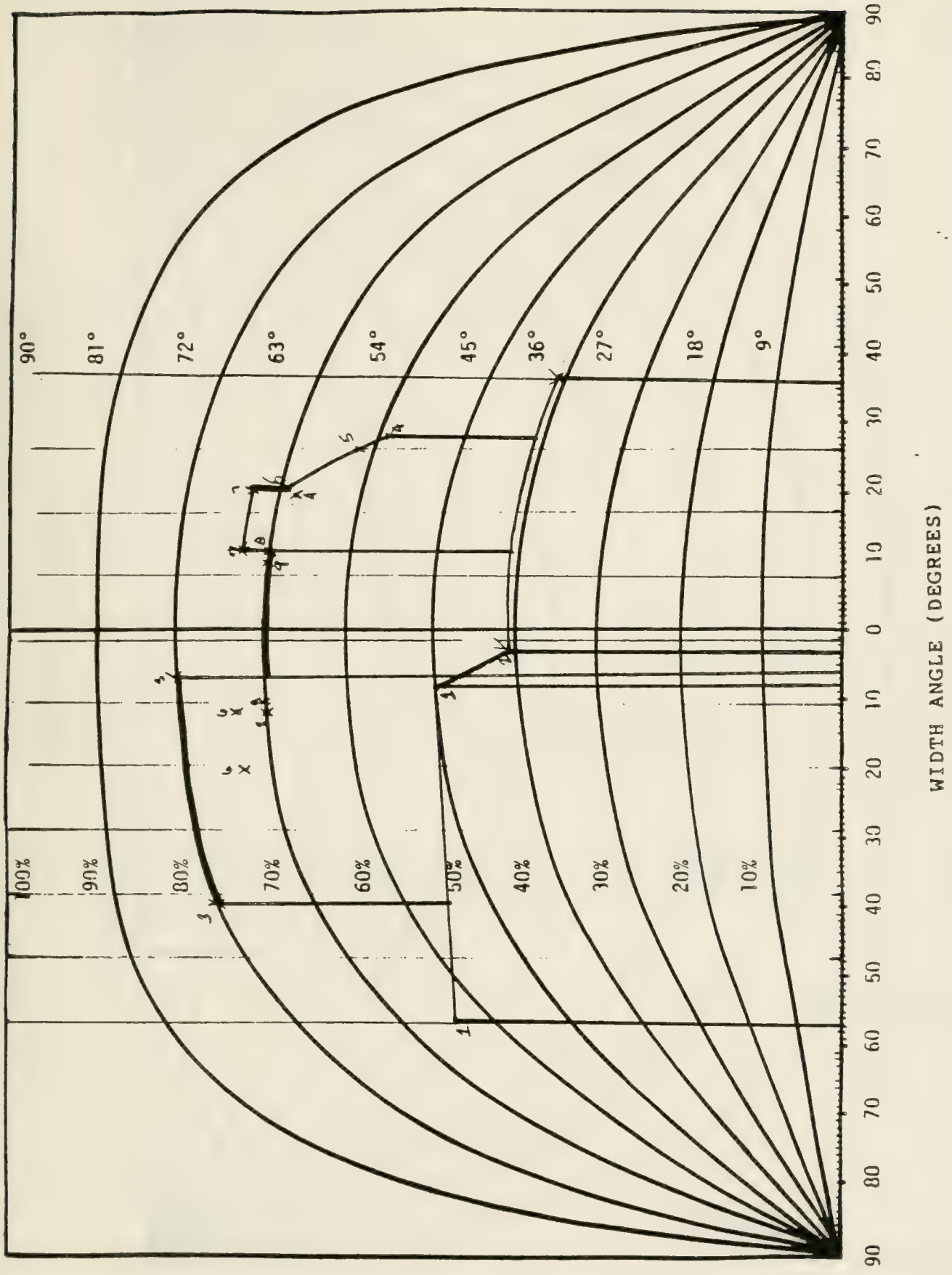

FIGURE 4.3.12 – 125 SUMMER STREET - SOUTH ELEVATION

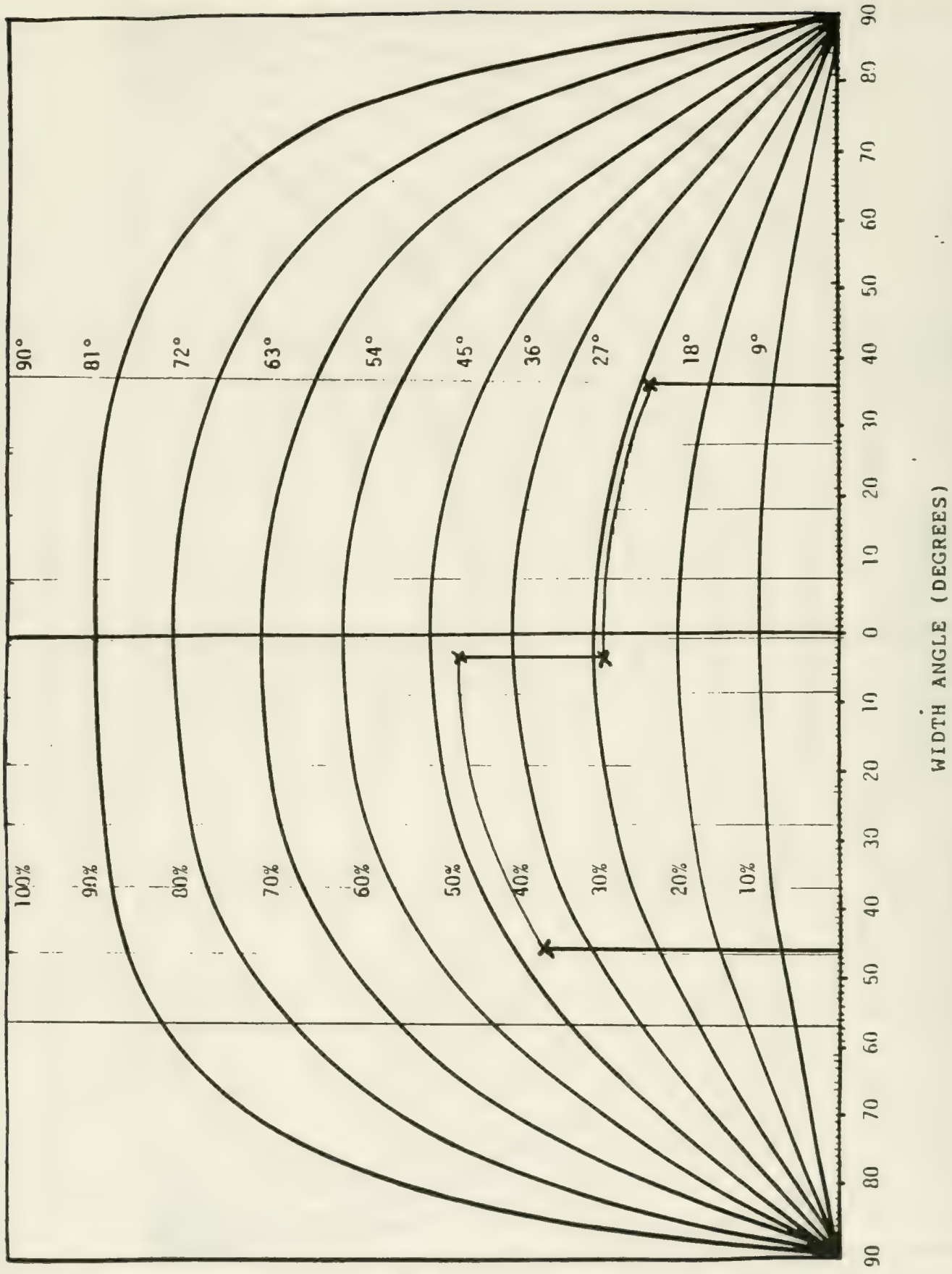

FIGURE 4.3.13 - EXISTING BUILDINGS - SOUTH ELEVATION

asymmetrical in comparison to others. The prominent features of the project from this point are its base, the 253 foot extention of the tower towards the south along Lincoln Street, and the tower section. Since much of the proposed building is set back considerably from the Surface Artery, only 69.5% of daylight is blocked from this observation point. Under the existing configuration 34% of available daylight is blocked.

West Elevation

Figures 4.3.14 and 4.3.15 present the "fish eye" view of the project and existing buildings, respectively from point A_W (see Figure 4.3.2) on Lincoln Street. From this location, the 73 foot base and 253 foot setback along Lincoln Street are the prominent features blocking daylight at ground level. The narrowness of Lincoln Street in combination with the project's design along Lincoln Street result in 87.5% of daylight blocked. The analysis demonstrated 76 percent of available daylight to be blocked by existing building. The bulk of the daylight obstructed by the proposed project is a result of only the 73 foot base section. In addition, the setback of the 253 foot tower section aids in preserving approximately 3 percent available sunlight.

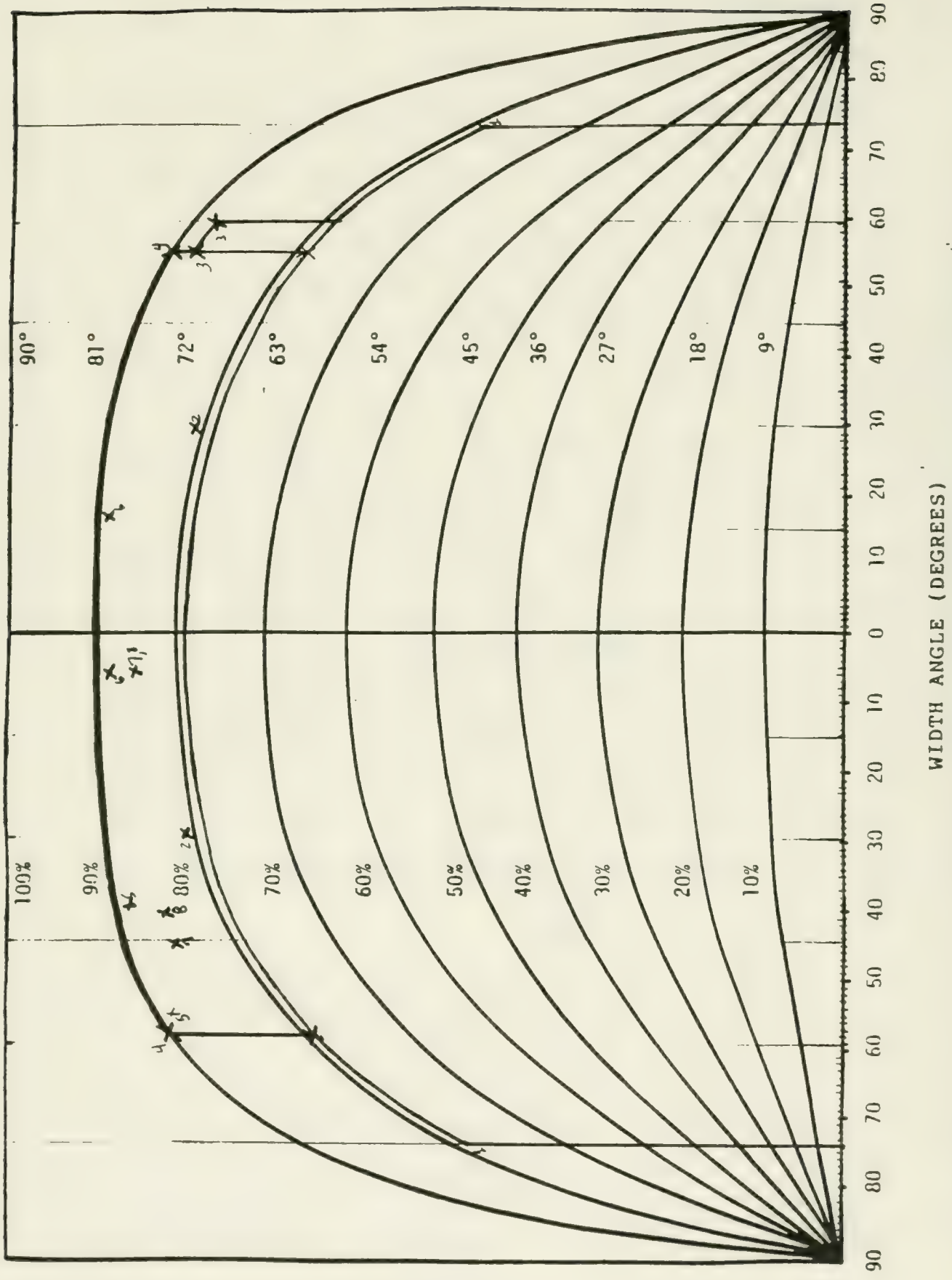

FIGURE 4.3.14 - 125 SUMMER STREET - WEST ELEVATION

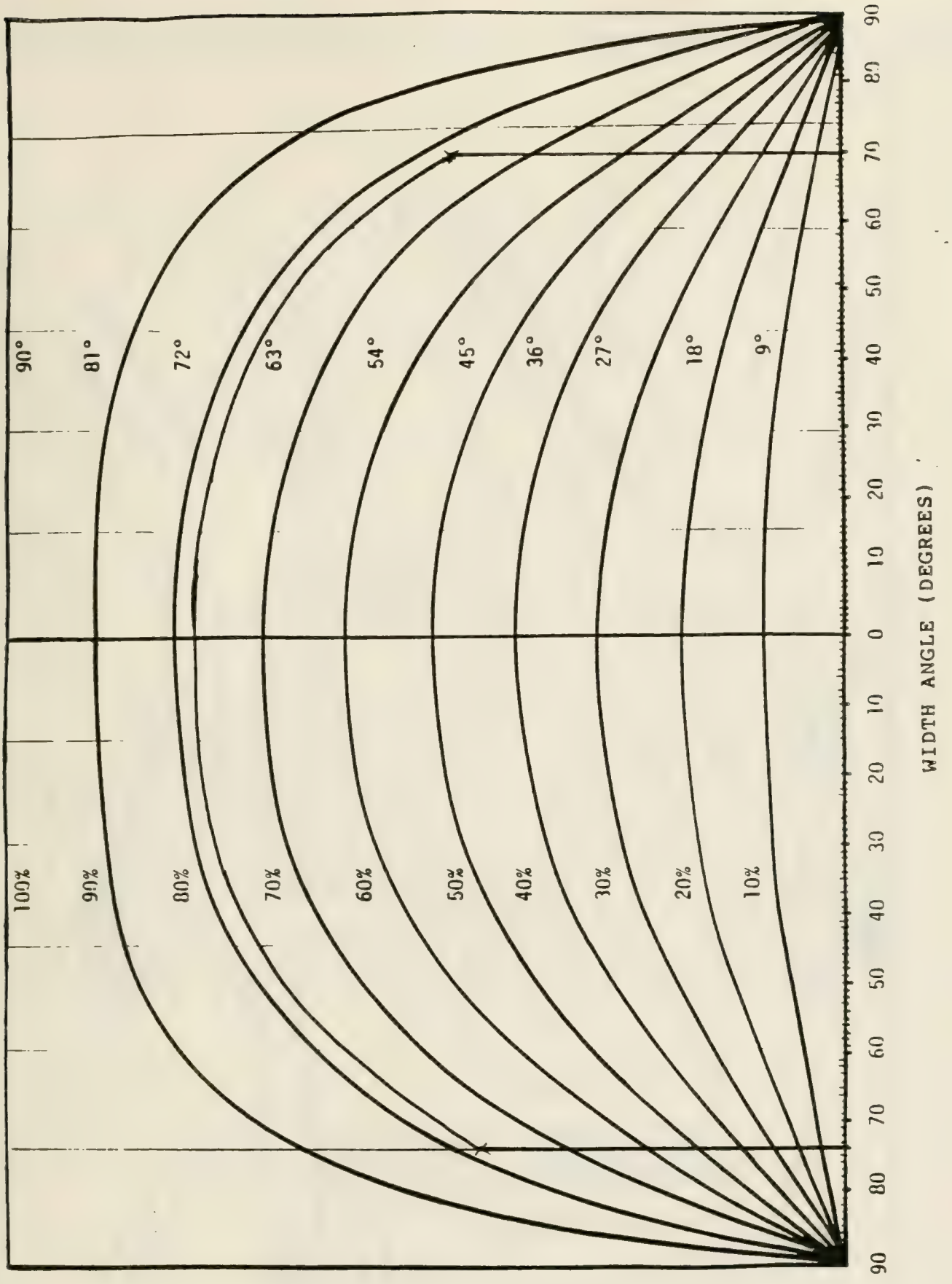

FIGURE 4.3.15 - EXISTING BUILDINGS - WEST ELEVATION

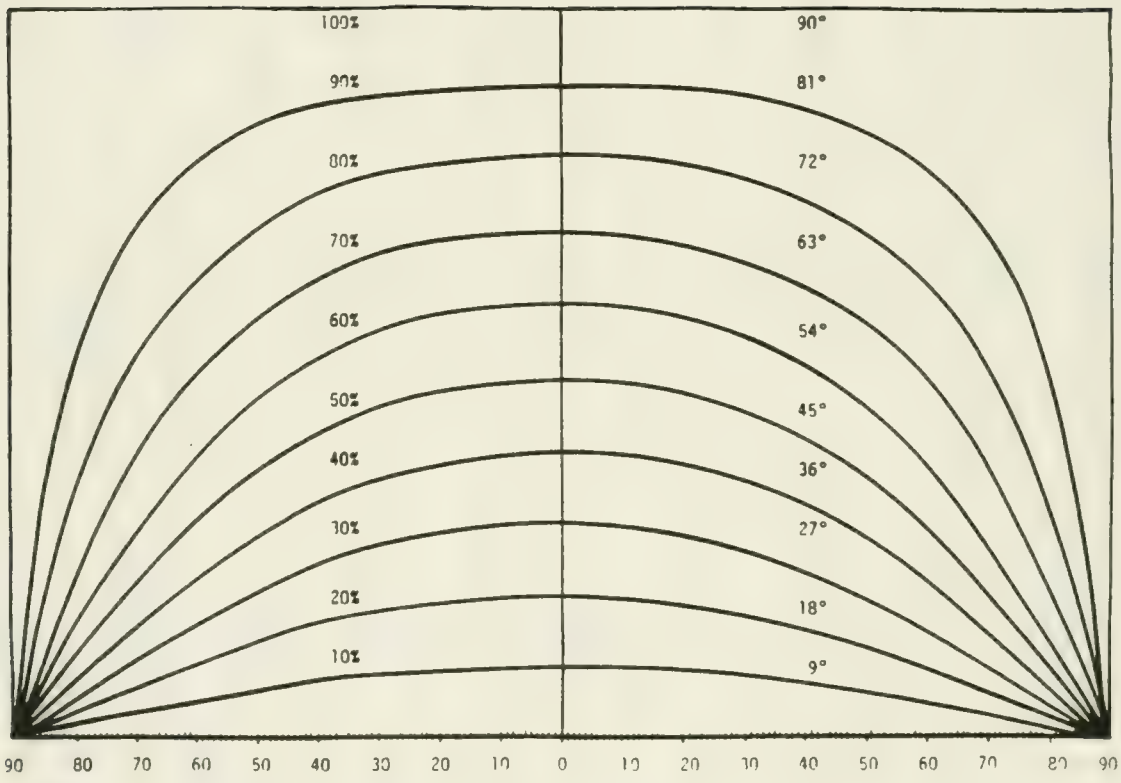

FIGURE 4.3.1 - "FISH EYE" BASE MAP

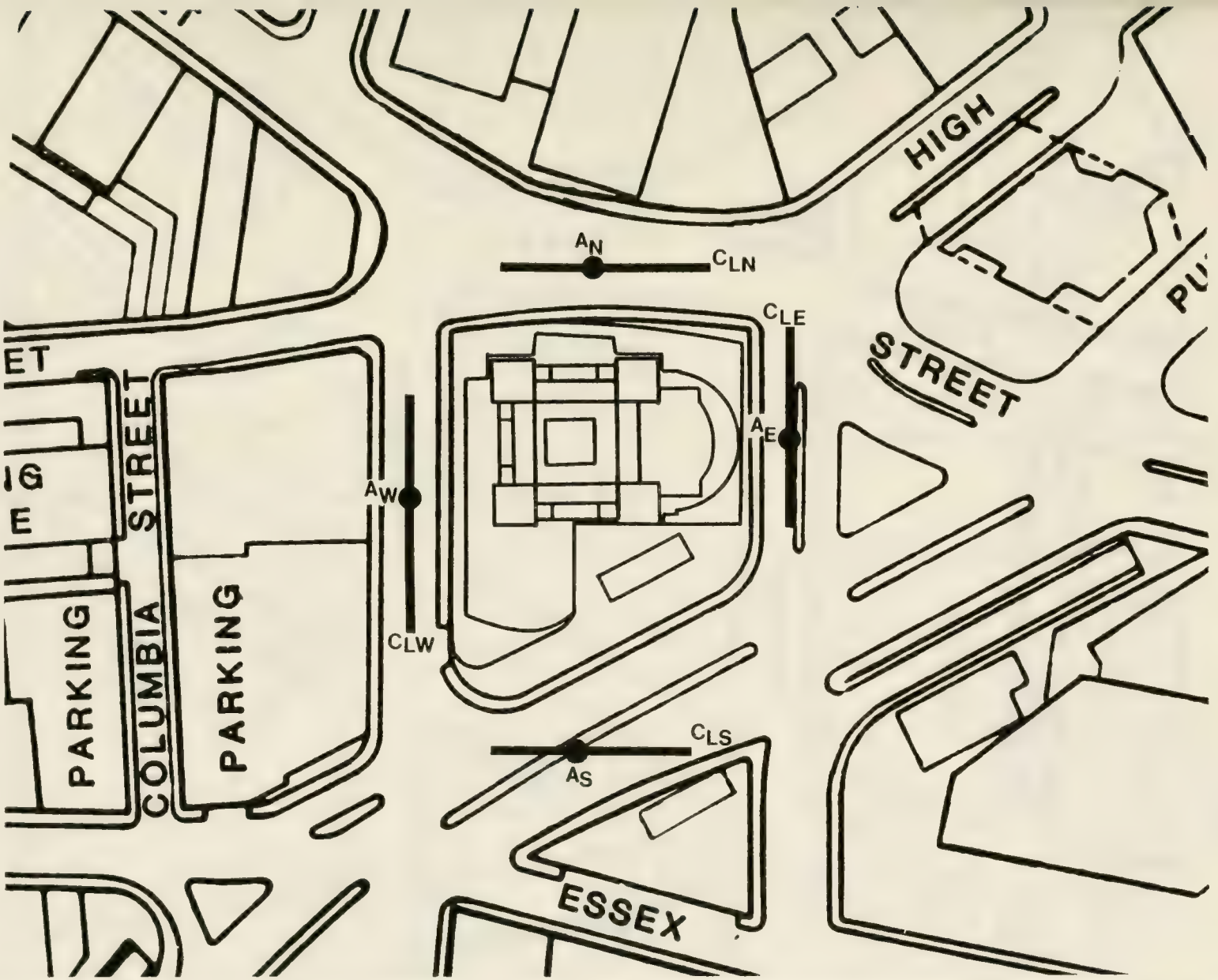

FIGURE 4.3.2 - PROPOSED PROJECT SITE

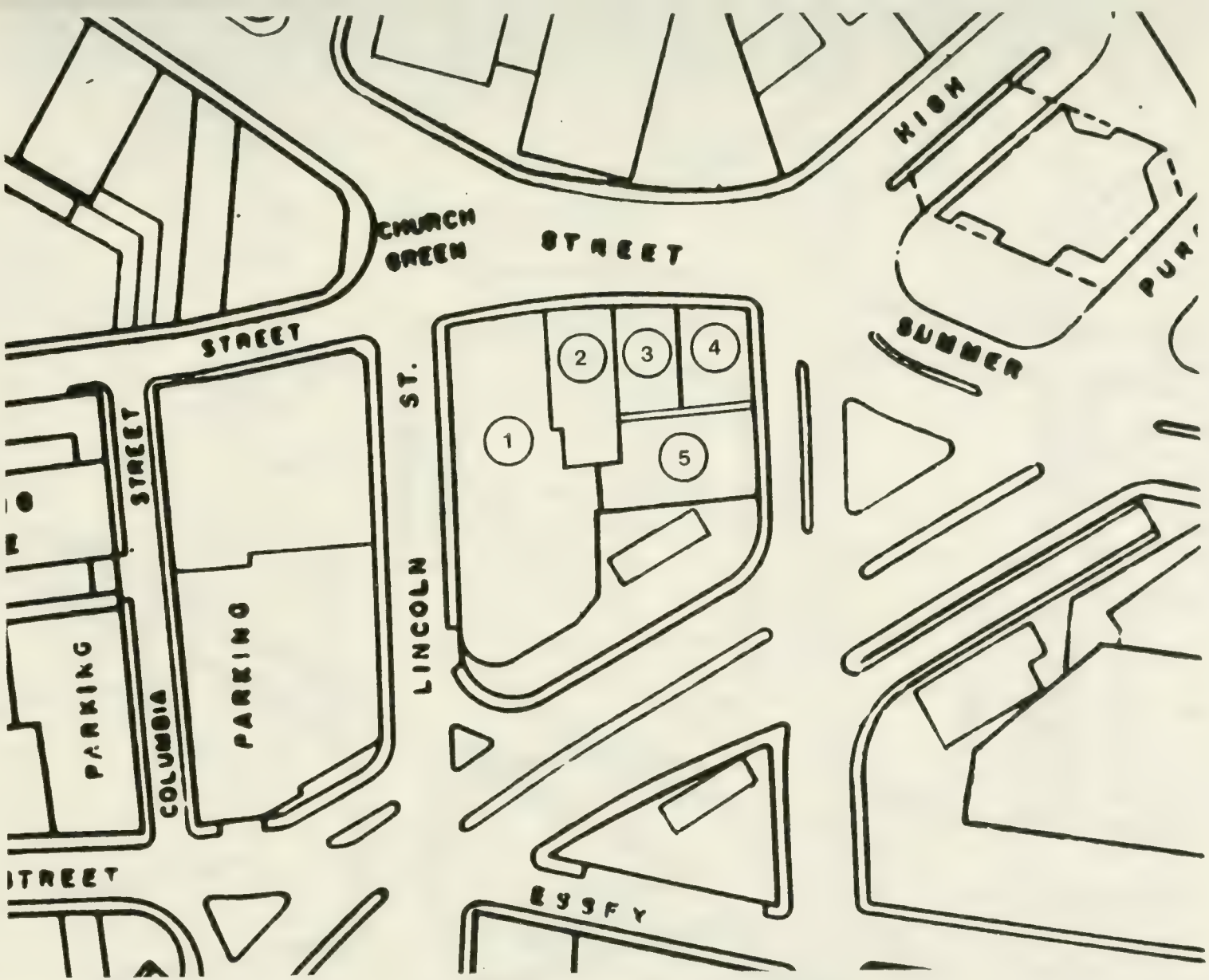

FIGURE 4.3.3 - EXISTING PROJECT SITE

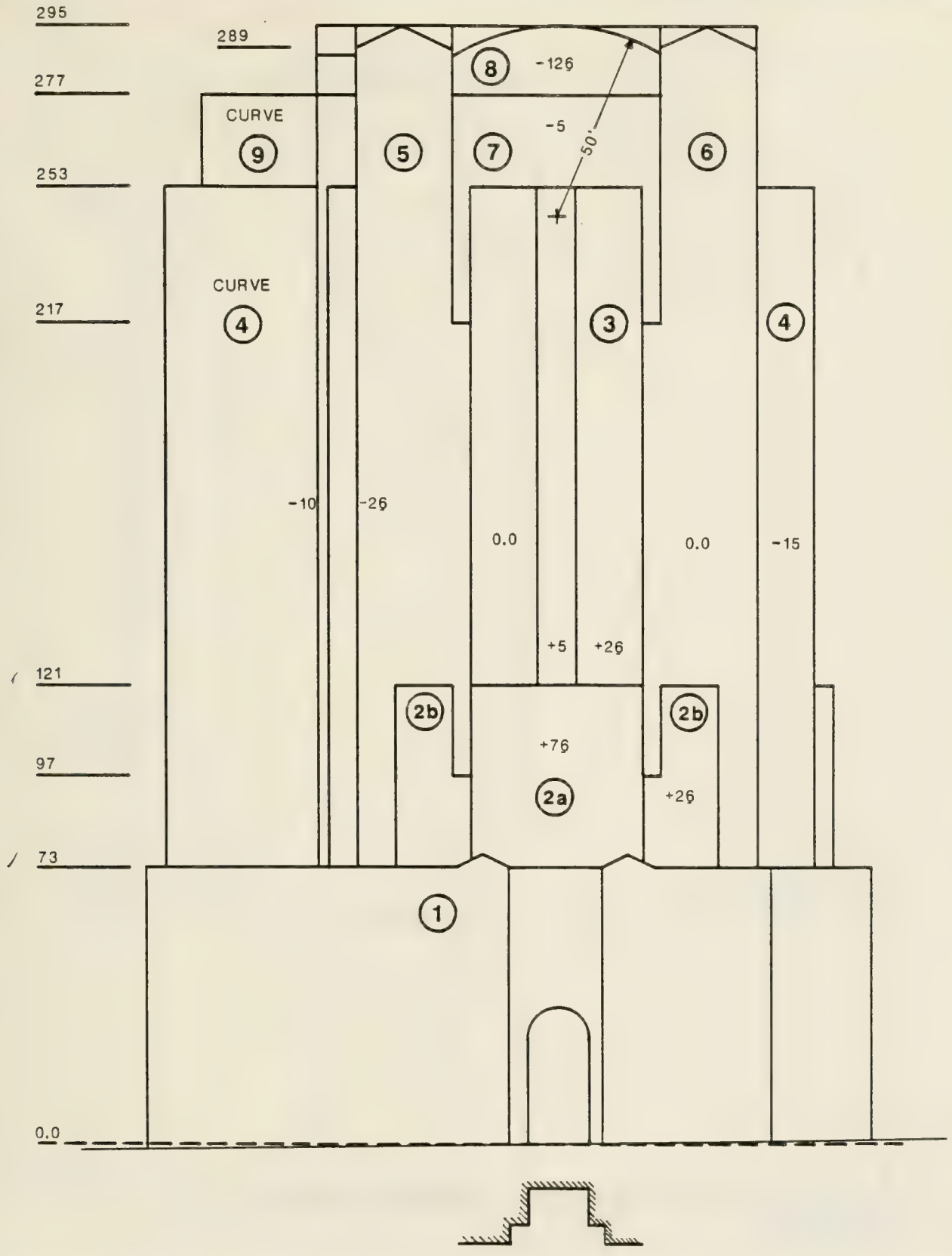

FIGURE 4.3.4 - NORTH ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

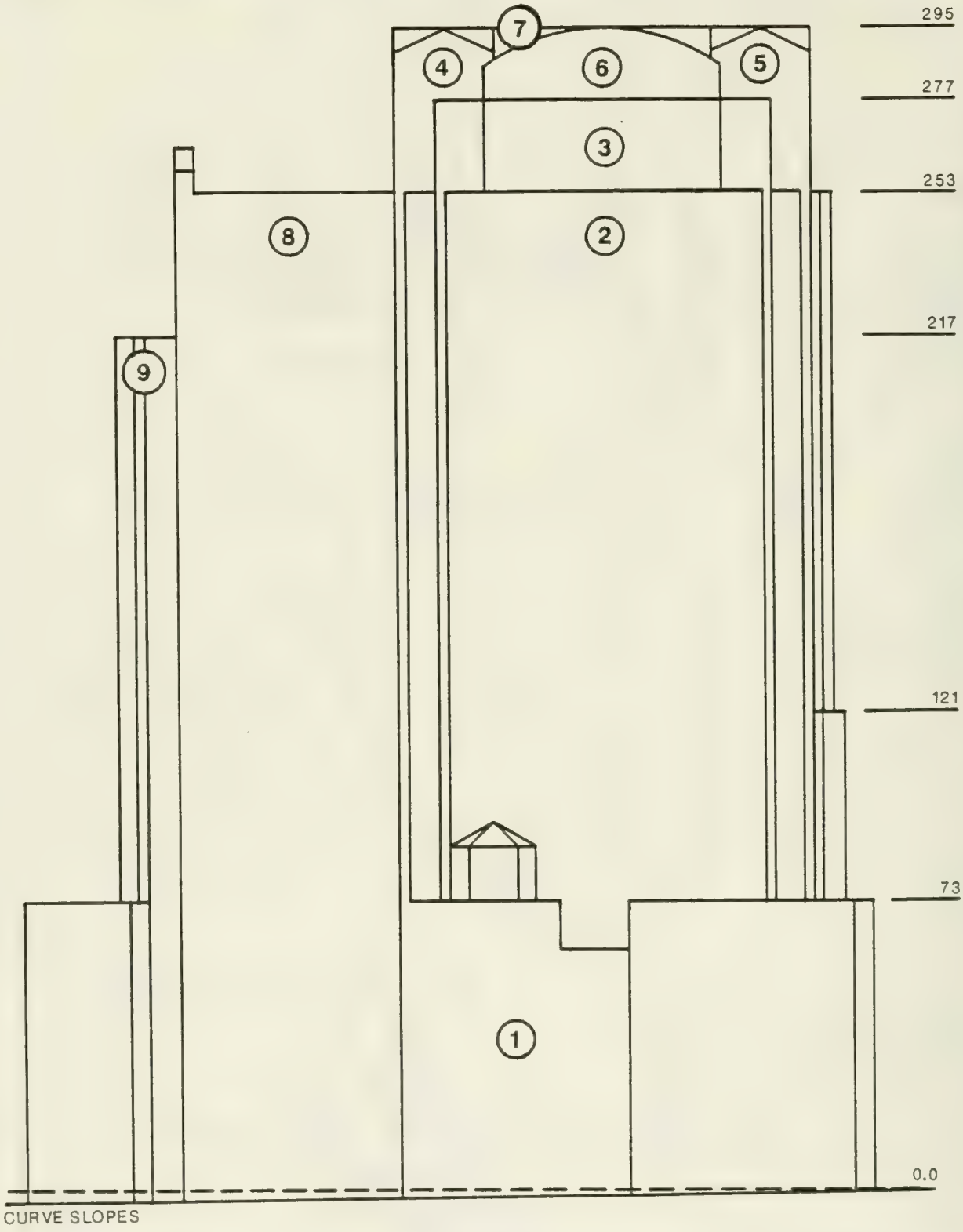

FIGURE 4.3.5 - EAST ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

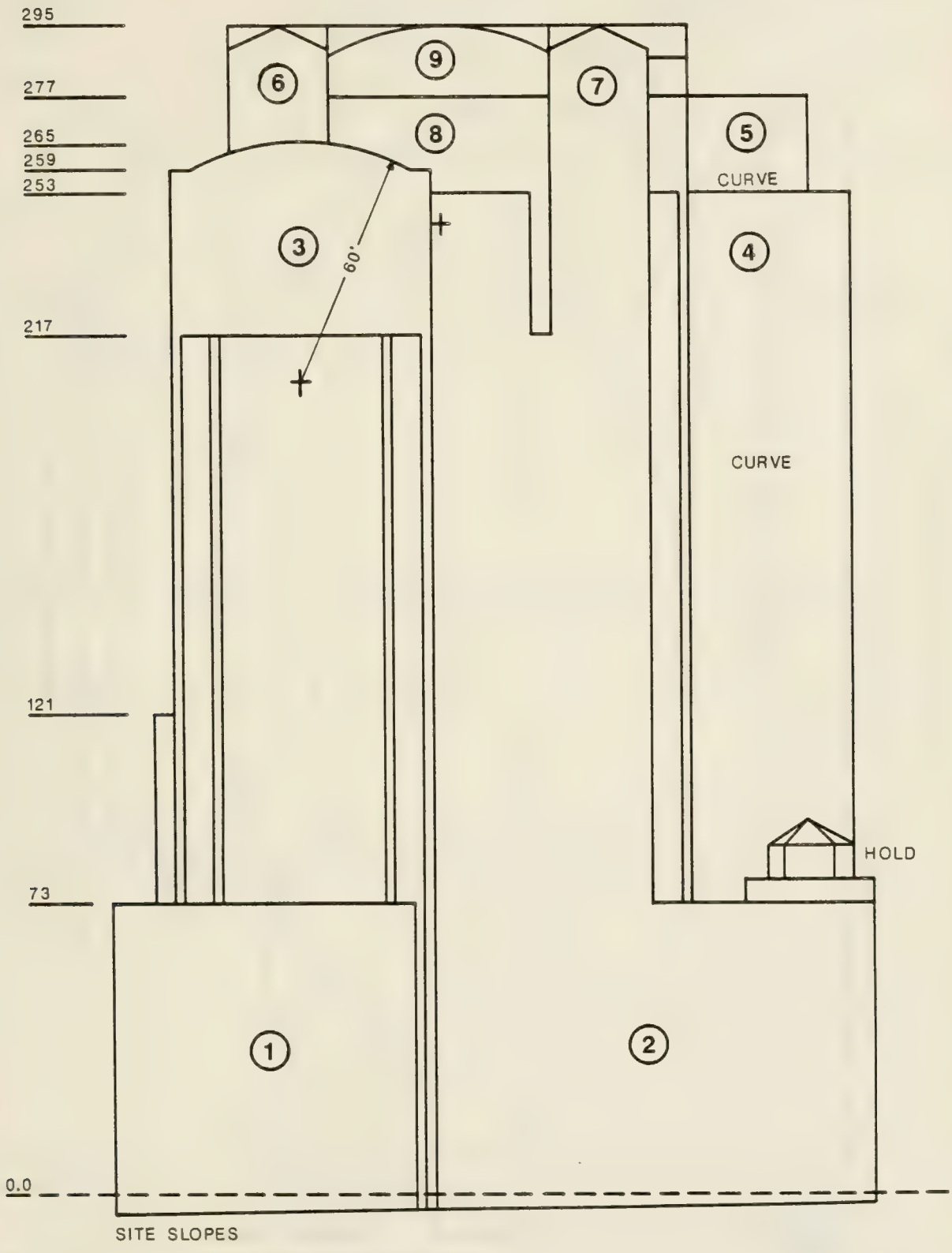

FIGURE 4.3.6 - SOUTH ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

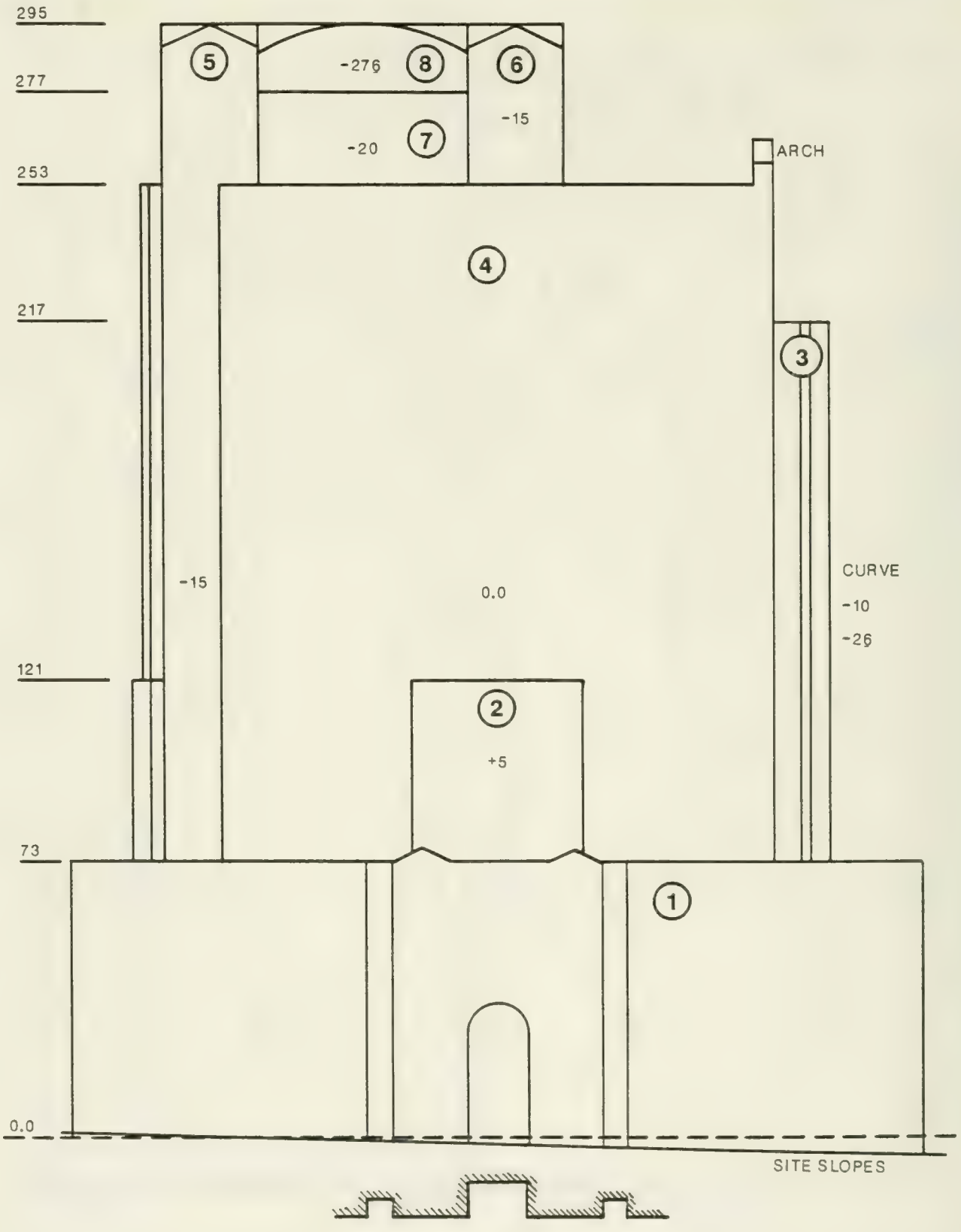

FIGURE 4.3.7 - WEST ELEVATION OF PROPOSED
125 SUMMER STREET PROJECT

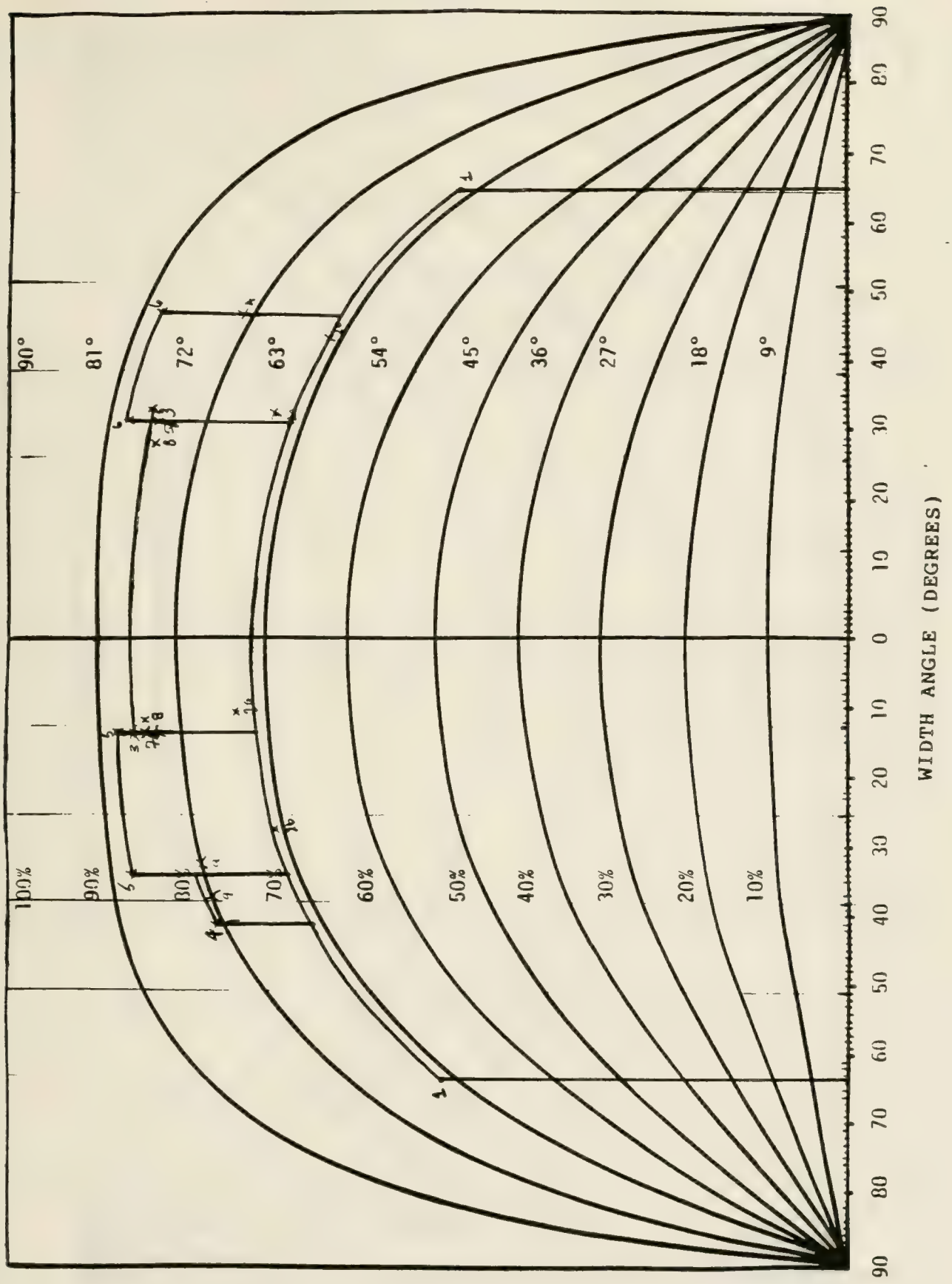

FIGURE 4.3.8 - 125 SUMMER STREET - NORTH ELEVATION

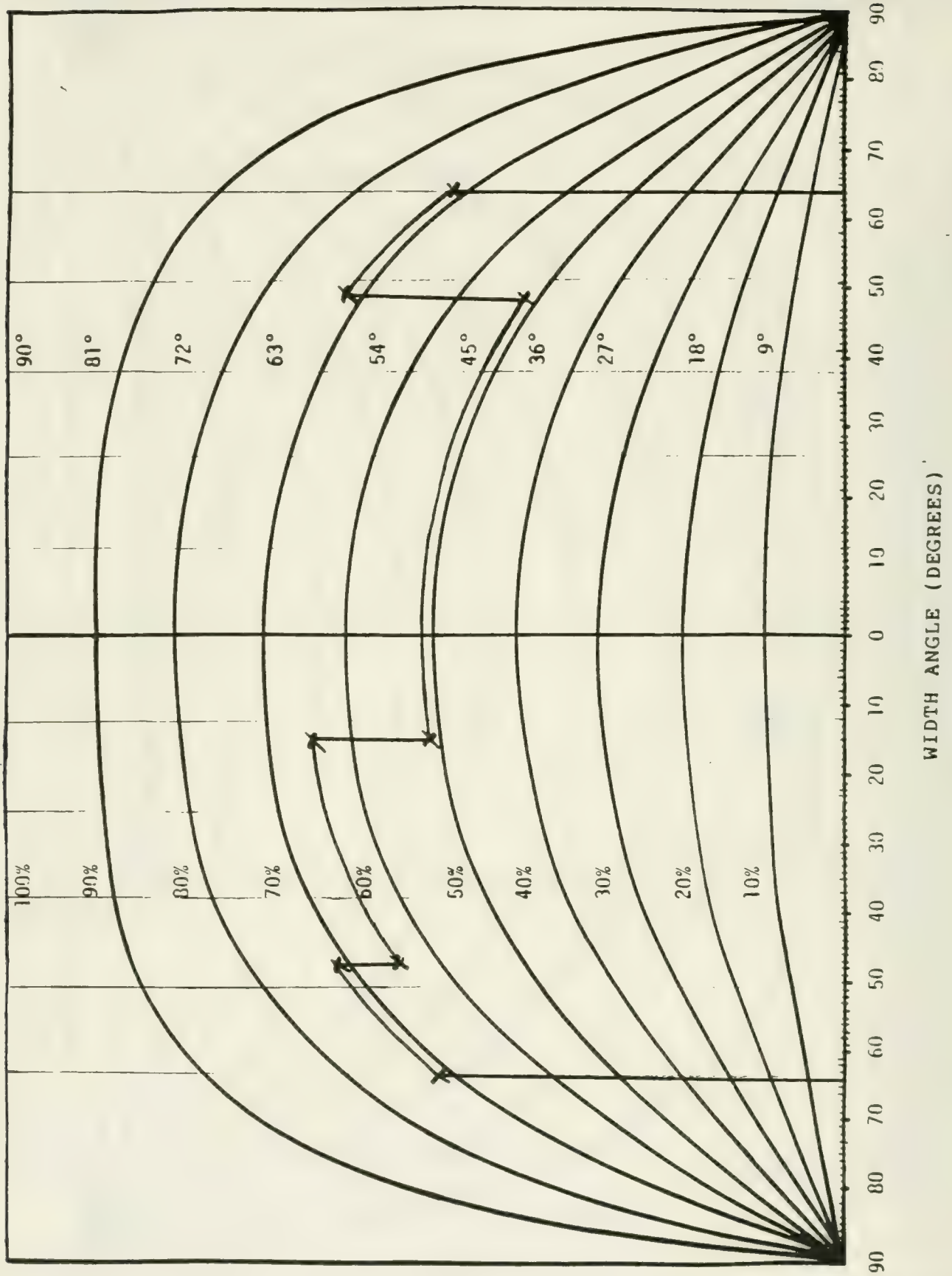

FIGURE 4.3.9 - EXISTING BUILDINGS - NORTH ELEVATION

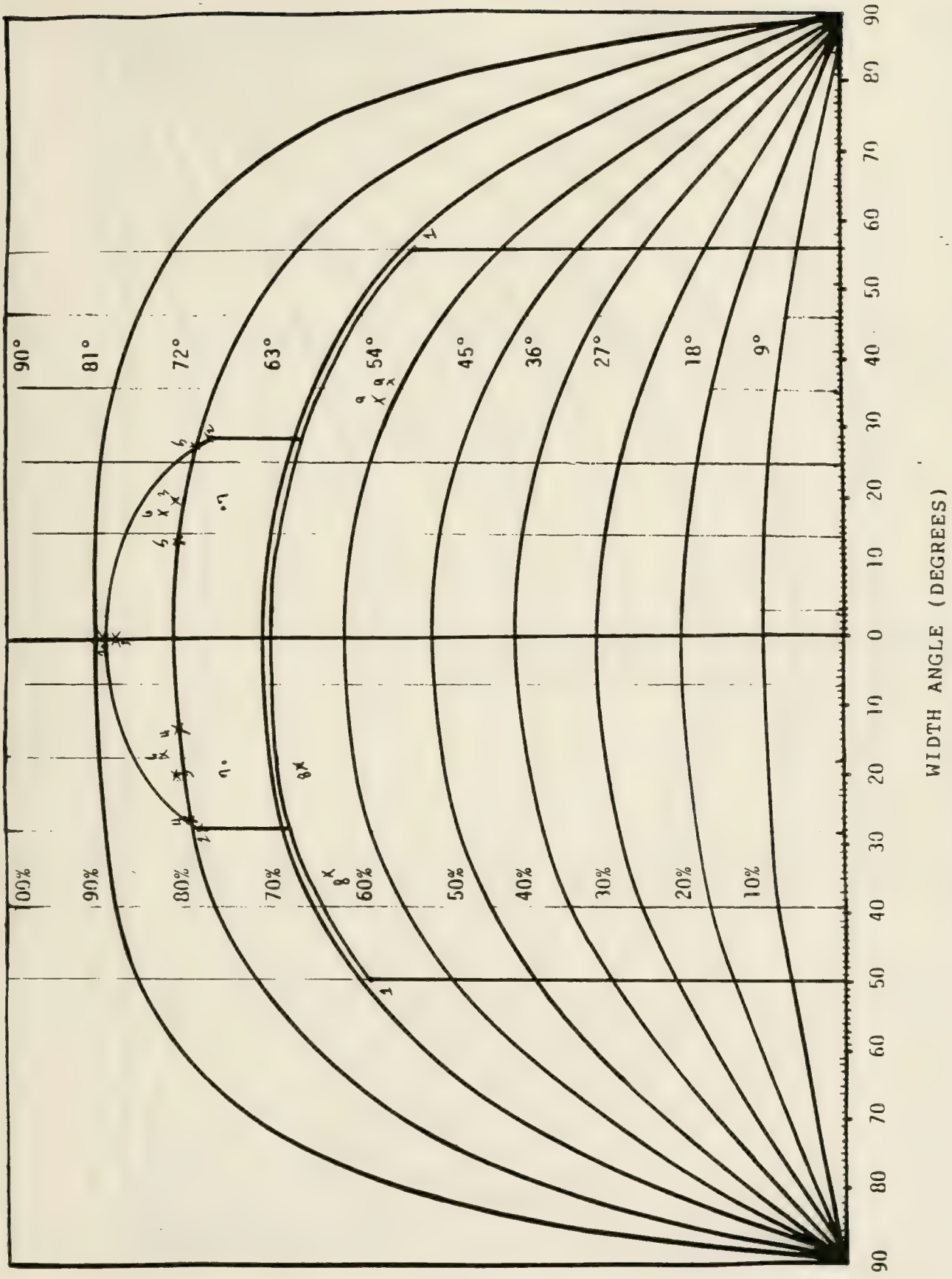

FIGURE 4.3.10 - 125 SUMMER STREET - EAST ELEVATION

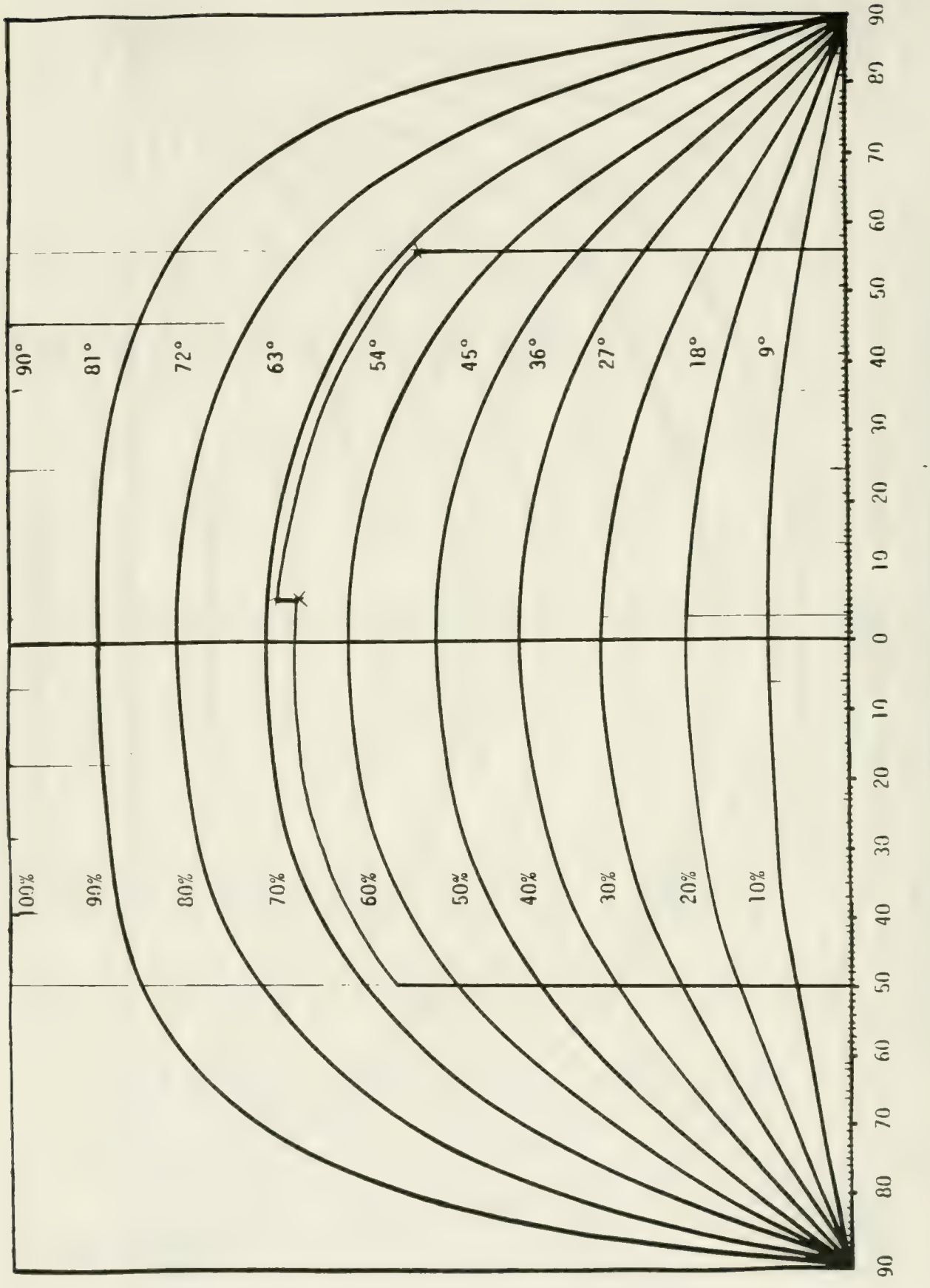

FIGURE 4.3.11 - EXISTING BUILDINGS - EAST ELEVATION

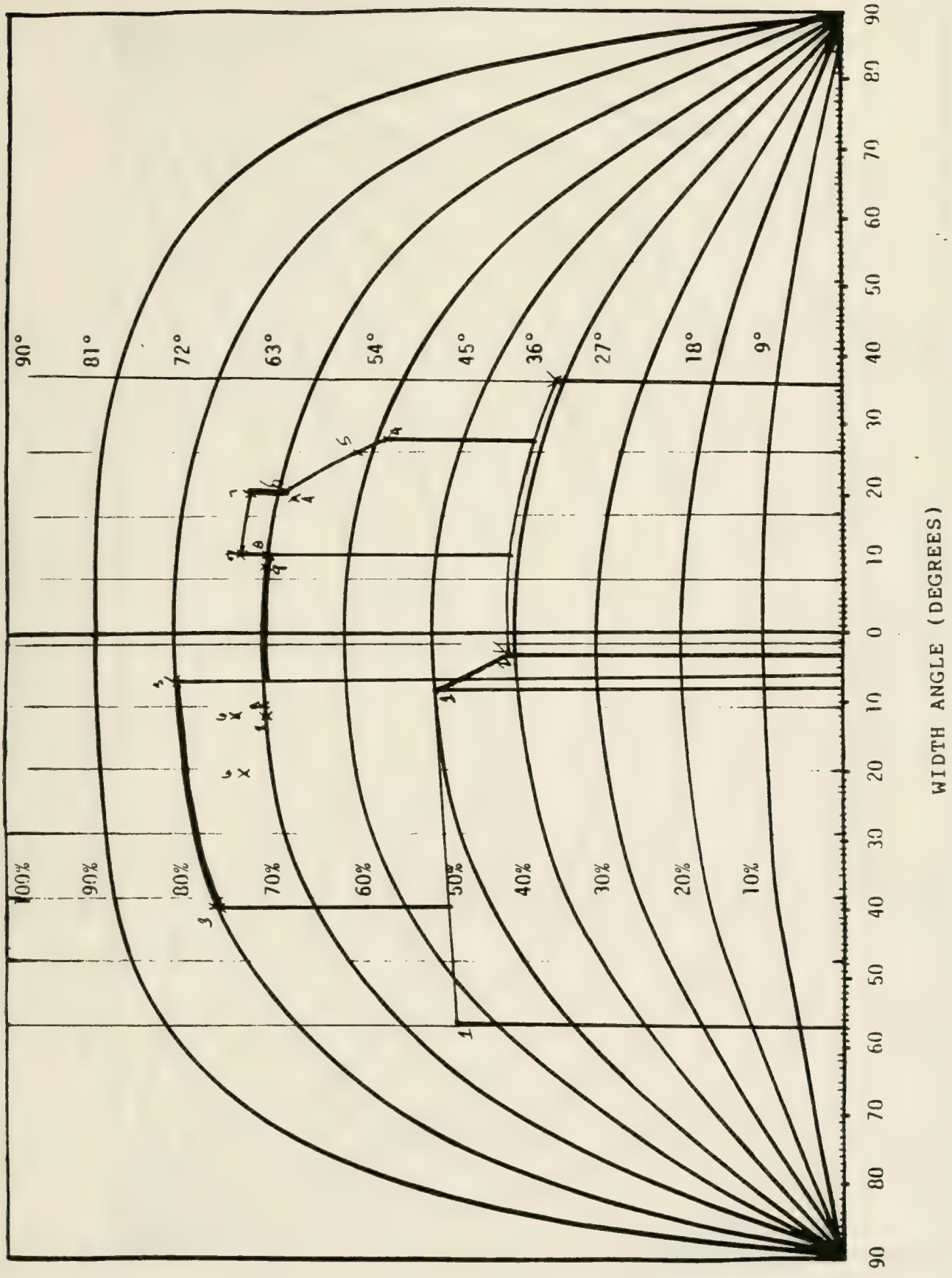

FIGURE 4.3.12 – 125 SUMMER STREET - SOUTH ELEVATION

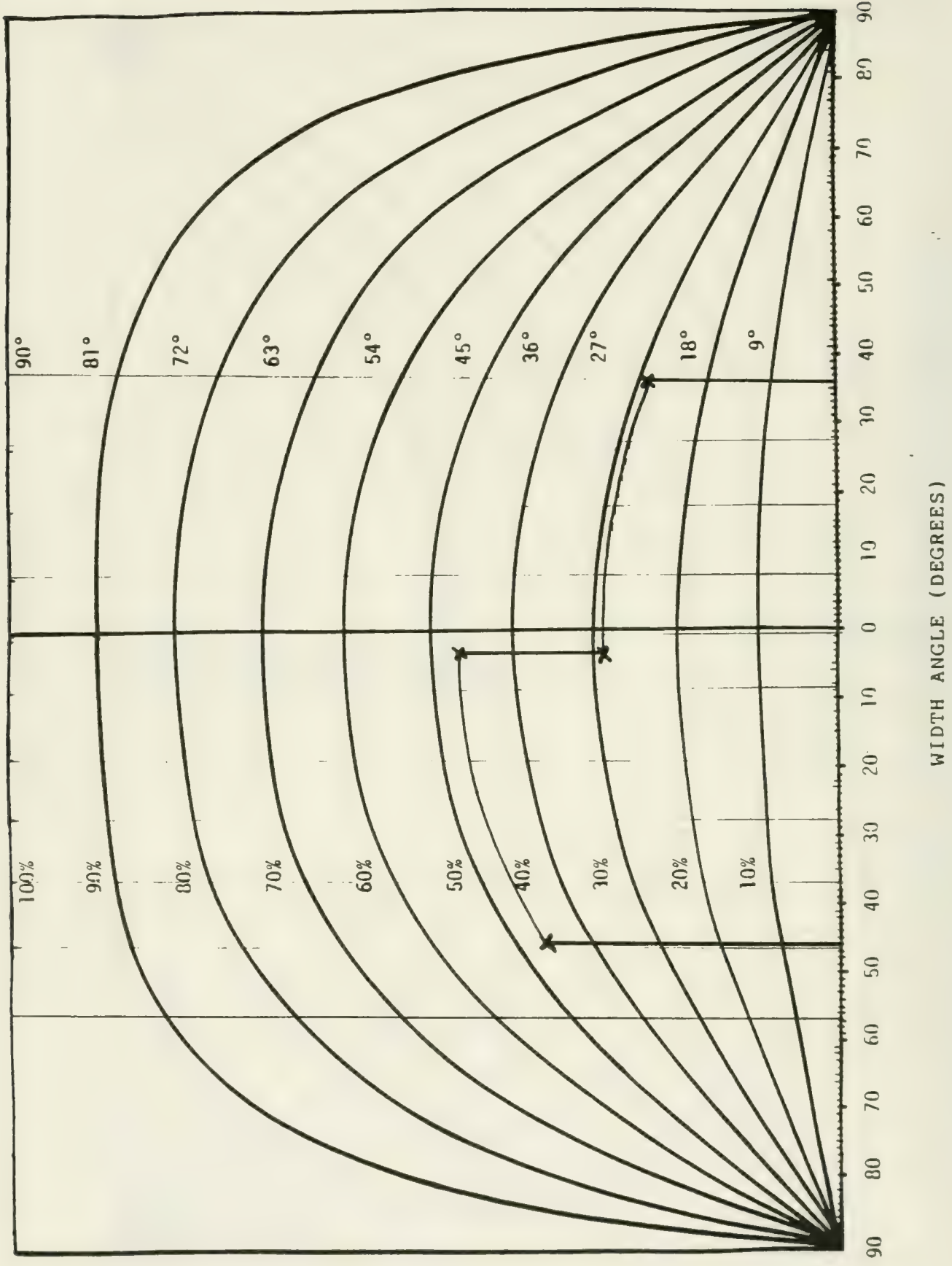

FIGURE 4.3.13 - EXISTING BUILDINGS - SOUTH ELEVATION

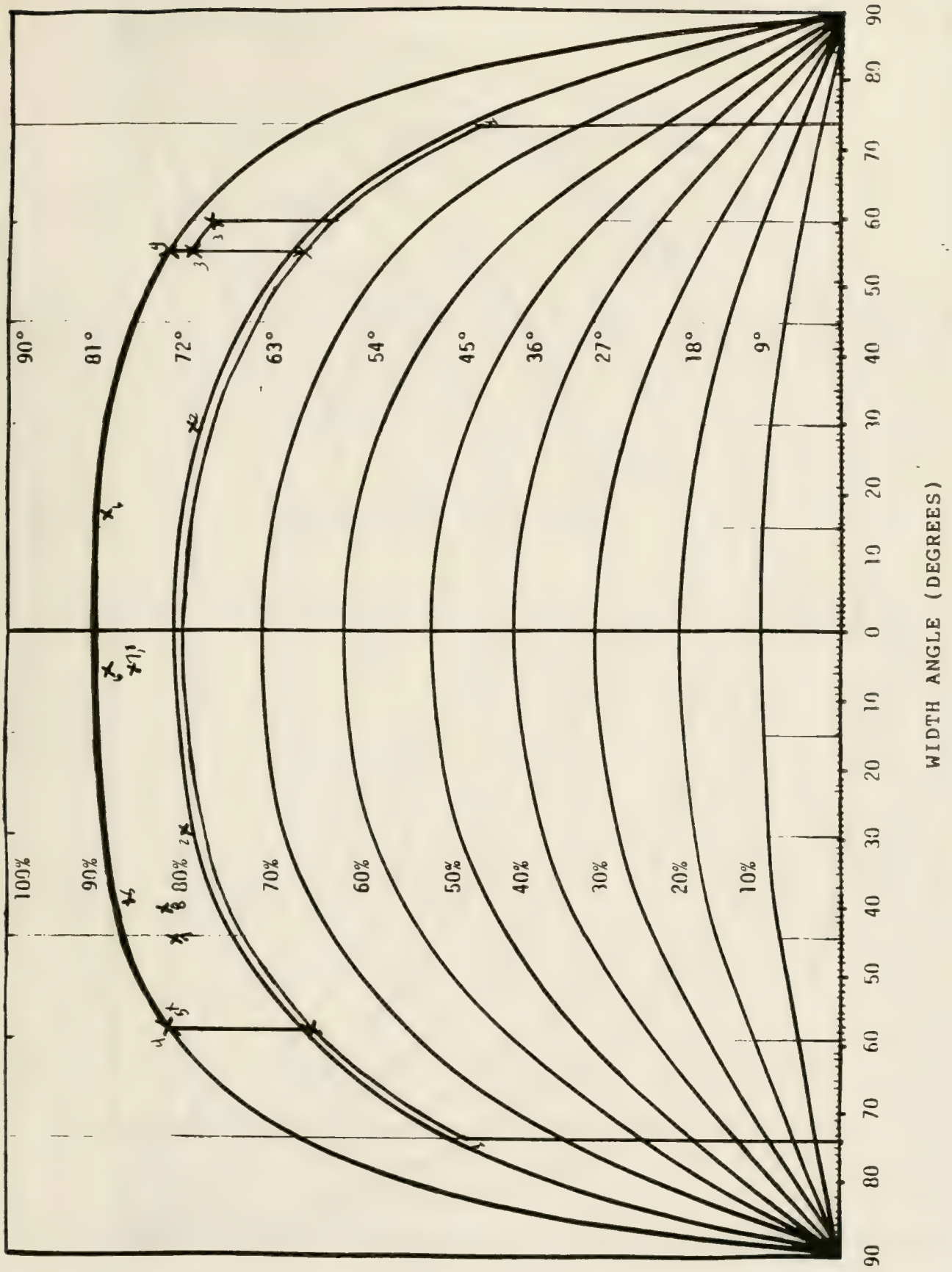

FIGURE 4.3.14 - 125 SUMMER STREET - WEST ELEVATION

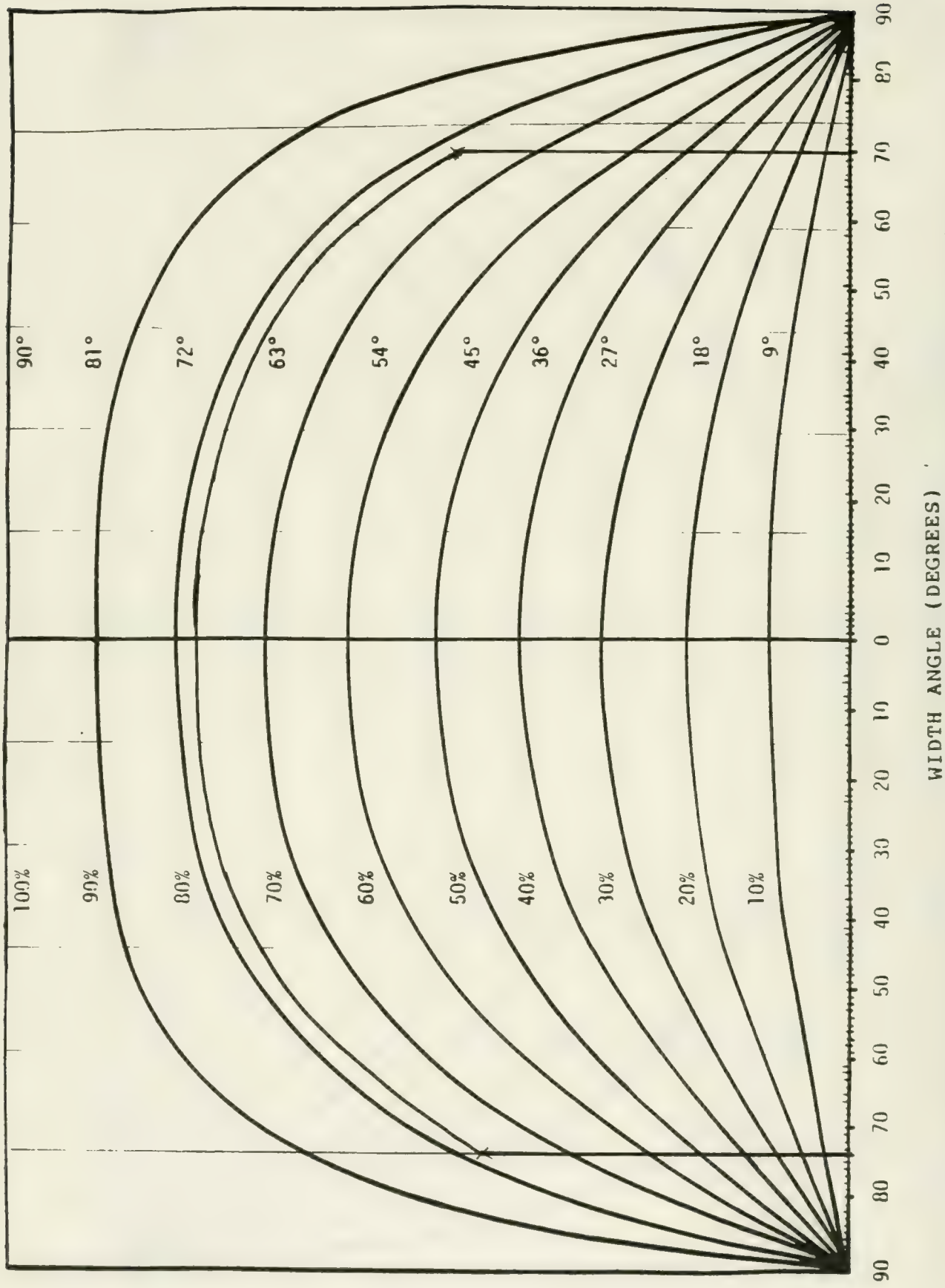

FIGURE 4.3.15 - EXISTING BUILDINGS - WEST ELEVATION

4.4 TRANSPORTATION IMPACTS

4.4.1 INTRODUCTION

This section describes existing traffic related conditions in the project study area, estimates the impact of the development in terms of vehicle, transit and pedestrian trips to the site, and provides an analysis of the study area under existing and future (1989) conditions. As a benchmark, it provides an analysis of conditions in the forecast year without the 125 Summer Street development but with other projects currently under construction or approved for development.

SUMMARY OF FINDINGS

Thirteen intersections were analyzed with regard to traffic impacts. The addition of project-related traffic to 1989 No-Build volumes results in four locations experiencing a change in level of service from No-Build conditions. Two of these intersections will continue to operate at Level of Service (LOS) "C" or better. The intersection of Surface Artery/Essex Street/Lincoln Street will decline from LOS "D" to LOS "E" in the morning peak hour and the Surface Artery/South Street/Expresssway On-Ramp intersection will decline from LOS "C" to LOS "D" in the evening peak hour.

Between 1985 and 1989, transit use is expected to increase by almost 25 percent based on background growth in the Downtown area. With the MBTA now in the final stages of improvements on both the Orange and Red Lines, an expansion from four-car to six-car trains is anticipated prior to 1989 on both lines. This, coupled with new equipment on the Green Line, will result in a substantial increase in transit capacity. Nevertheless, under

projected conditions the Orange Line north, Green Line west and Blue Line will operate over planning capacity.

The 125 Summer Street development will include the construction of below-grade parking which is proposed to contain up to a maximum of 400 spaces. The analysis indicates that the long-term commuter parking demand associated with the project will be 362 spaces. Short-term, non-employee demand is expected to be 95 spaces.

Finally, the report includes a proposed Access Plan which identifies actions to reduce the impact of development. Included in the Access Plan are commitments by the proponent to take steps to reduce and better manage vehicular trip generation to the site and to design access to the building in order to minimize impacts on adjacent streets. Trip reduction efforts include measures to promote ridesharing and transit use, to encourage alternative work schedules, to restrict truck deliveries to non-peak hours, and to provide administrative support for trip reduction/ management efforts.

THE 125 SUMMER STREET PROJECT

The proposed development will consist of 495,000 square feet of office and retail development. Table 4.4.1 summarizes the proposed development of the site, which will include 482,000 square feet of office space and 13,000 square feet of retail space. The site encompasses most of the block bounded by Summer Street, South Street, Surface Artery and Lincoln Street. Several low-rise buildings occupy the site but are currently unused.

TABLE 4.4.1
PROPOSED DEVELOPMENT

Use	Size (square feet)
Office	482,000
Retail	13,000
Total	495,000
Parking spaces	400

STUDY AREA

The study area defined for this project includes 13 intersections within a perimeter bounded by Atlantic Avenue to the east; Congress Street on the north; High Street, Summer Street, Lincoln Street and Surface Artery on the west; and Kneeland Street on the south. The site location and 13 analysis locations are illustrated in Figure 4.4.1.

Public transportation in the area of the project is well developed and utilized. Three of the MBTA's four rapid transit lines may be directly accessed from four stations within 2,000 feet of the site, the closest being South Station (Red Line) and Washington Street (Orange and Red Lines). Blue Line rapid transit, commuter rail service from South Station, commuter boats, and express buses to the south and west are all accessible within one-half mile of the site.

STUDY METHODOLOGY

The transportation study was conducted in three distinct phases. Phase I involved inventorying the existing conditions and travel demand characteristics in the area. The inventory included researching previous transportation reports as well as

Site Location and Study Intersections

LEGEND:

Intersection Study Location

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SCALE: 1"=400'

Fig. 4.4.1

conducting new observations of the area travel demands. Observations of traffic volumes were conducted during the morning and evening peak periods at key intersections serving the site. These counts included pedestrian crossings. In addition, transit line performance and ridership data were researched from MBTA files.

Phase II of the study built upon the data base in Phase I and established the framework for evaluating the transportation impacts of the proposed project. In this phase, travel demand forecasts for the project were assessed along with forecasted demands created by other future area developments. An analysis year of 1989 was established based on projected occupancy of the proposed development. Estimates were made for all transportation modes.

Phase III, the final study phase, included evaluation of the impacts of the project on the transportation and pedestrian system and identification of measures to mitigate any adverse impacts. Included within this effort was the development of an Access Plan for the development.

4.4.2 EXISTING CONDITIONS

ROADWAY NETWORK

In addition to Summer Street, roadways in the area which will provide access to the immediate site include South Street, Lincoln Street and Surface Artery. Access to and from the regional highway system is provided by the Central Artery and Atlantic Avenue. Figure 4.4.2 illustrates the roadway circulation pattern now existing in the area. The following provides a brief summary of roadway characteristics:

- Central Artery - a major north/south artery east of the site with connections to the Southeast Expressway, the Massachusetts Turnpike and major routes north. It is a divided roadway providing three travel lanes in each direction.

- Surface Artery - a major north/south artery east of the site running above the depressed Central Artery. It is a divided roadway providing three travel lanes in each direction.

- Summer Street - a major east/west arterial linking the Downtown Crossing area to Dewey Square and to South Boston across the Fort Point Channel. The number of lanes varies from one to three in each direction with no parking on either side.

- Atlantic Avenue - a north/south arterial which parallels the Central Artery north and generally provides two to three lanes for one-way northbound traffic. Two southbound lanes are provided for one block between Summer Street and Essex Street.

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LEGEND:

Site

Direction Of Travel

SCALE: 1"=400'

Study Area Circulation

Fig. 4.4.2

- Purchase Street - a one-way arterial paralleling the Central Artery which provides two to three lanes southbound to Summer Street from High Street.

- High Street - a major one-way connector providing two lanes southbound from the Central and Surface Arteries to the site. Two-way travel is permitted between Summer Street and Federal Street.

- South Street - a moderate volume one-way street providing two lanes northbound from Kneeland Street to High Street.

- Lincoln Street - a major one-way connector providing two lanes northbound from the Southeast Expressway and Kneeland Street to Summer Street and the project site.

EXISTING TRAFFIC VOLUMES

Estimates of existing peak hour volumes are shown in Figures 4.4.3 and 4.4.4. These volumes are based on 1987 projected volumes used for the Draft Environmental Assessment of the Dewey Square Comprehensive Transportation Systems Management Program. Currently, there are several construction projects underway within or near the study area which are affecting normal traffic patterns. These construction projects include:

- Dewey Square - Red Line station platform lengthening by the MBTA and utility construction;

- South Station - Rehabilitation of the South Station headhouse and development of the first phase of a multi-modal transportation center;

- Summer Street at Washington Street - Red Line station platform lengthening by the MBTA;

- International Place - Construction of high-rise office and retail development between High Street, Purchase Street and Oliver Street;

- Rowes Wharf - Construction of office, retail, residential and hotel development along Atlantic Avenue; and

- Construction and rehabilitation at several other sites in the area.

Because of this extensive amount of construction activity currently taking place in the study area, substantial diversions of traffic from normal preconstruction patterns are assumed to have occurred. As a result, an extensive counting program would not be useful in establishing baseline conditions in the area. Therefore, a more appropriate approach was to use available base volumes that reflect normal traffic patterns. Such a base exists as a result of the Dewey Square study referenced above. That study included both 1980 base conditions and 1987 projections.

Several intersections were recounted to provide a comparison to the projected 1987 volumes from the Dewey Square report. The intersections selected covered the entire study area but were generally the most removed from areas of immediate construction impacts. Generally, approach volumes were close to those reported in the 1987 network for the Dewey Square project. Where significant differences exist, the 1986 counts were either lower or the differences could be explained by construction-induced diversions. Therefore, the 1987 No-Build network from the Dewey Square study was used as the base network for this study because those volumes are the most representative of existing conditions

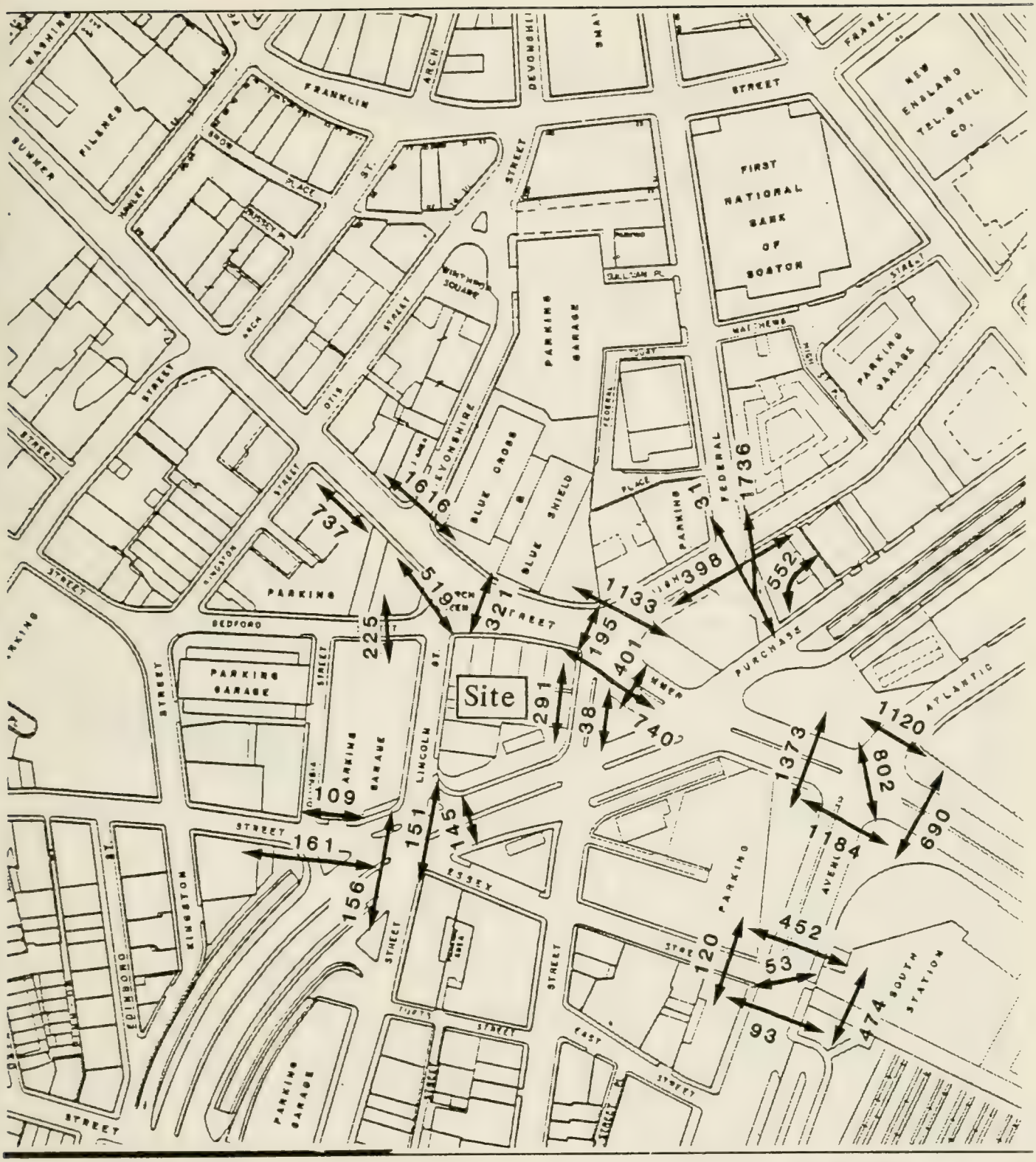
without construction disruptions. This approach was discussed with the Boston Transportation Department, which concurred with it.

Before being finalized as the base volumes for this study, the 1987 Dewey Square No-Build volumes were adjusted to reflect the current one-way travel on Essex Street. The Dewey Square network was developed with Essex Street as a two-way street. The adjustment involved the reassignment of projected westbound volumes along Essex Street to alternative routes in the area.

Additional adjustments were also made to assure consistency with the network being developed for the 125 High Street EIA. Both networks were compared with base volumes from the International Place EIR and other EIR's and impact reports for downtown development. In general, the networks are consistent with those developed for earlier studies and show the same or higher volumes when compared with the International Place base network.

EXISTING PEDESTRIAN VOLUMES

Pedestrian volumes along Summer Street between the project site and Dewey Square are summarized in Table 4.4.2 and shown in Figures 4.4.5 and 4.4.6. At Dewey Square volumes are highest during the morning and evening peak hours, while along the remainder of Summer Street midday volumes are highest. The greatest pedestrian activity occurs at Dewey Square, where there were almost 6,000 crossings in the morning peak hour and almost 5,500 in the evening peak hour. Volumes along Summer street adjacent to the project site at Lincoln Street and South Street range from 520 to 740 in the morning peak hour and from 850 to 1,010 in the evening peak hour.



Existing
A.M. Peak Hour
Pedestrian Flows
7:30–8:30

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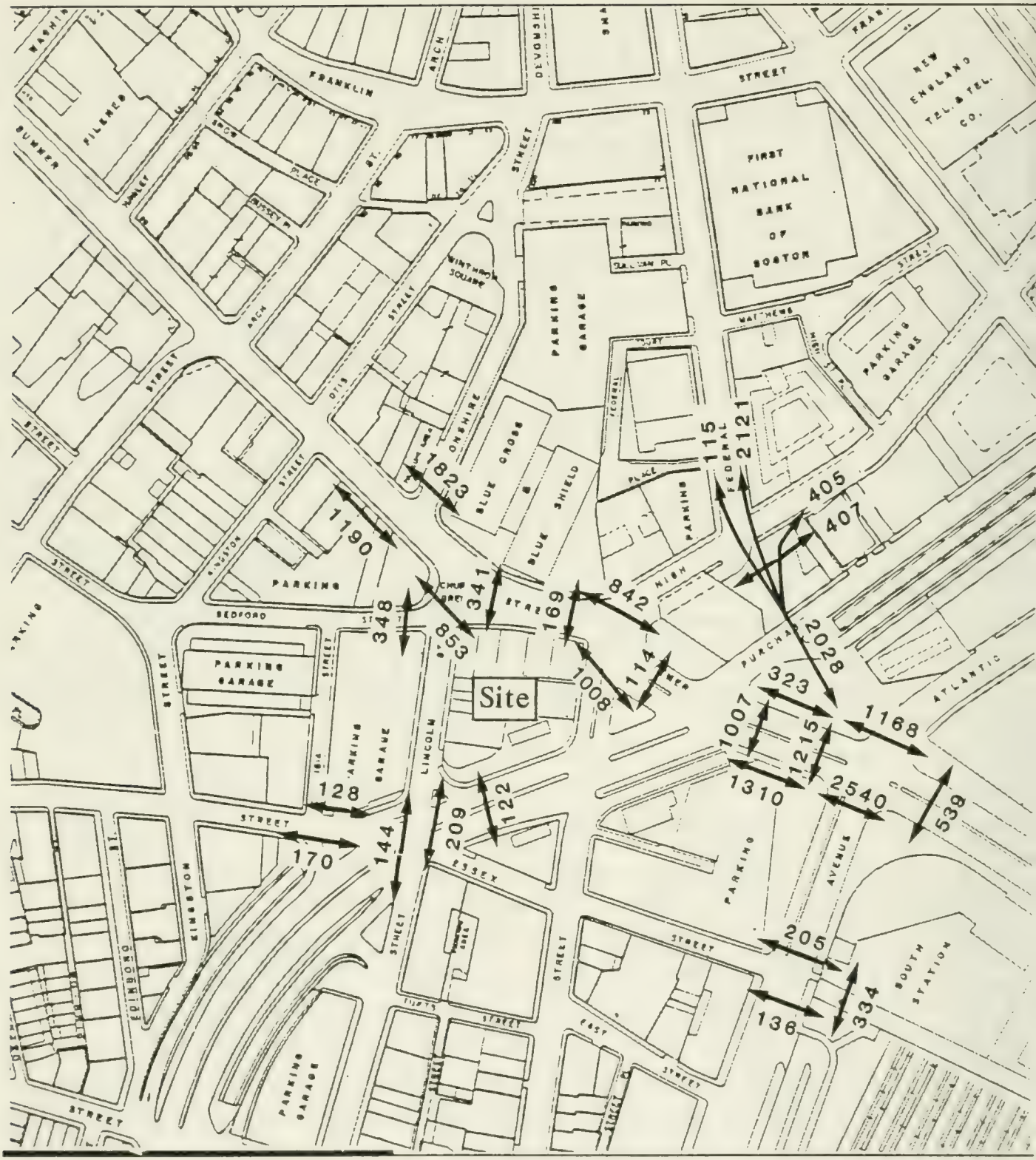
Scale: 1" = 200'

Fig. 4.4.5



Existing
P.M. Peak Hour
Pedestrian Flows
4:30–5:30

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Scale: 1" = 200'

Fig. 4.4.6

TABLE 4.4.2
EXISTING PEDESTRIAN VOLUMES
ALONG SUMMER STREET

Location	AM Peak Hour	Midday Peak Hour	PM Peak Hour
Summer Street/Atlantic Avenue (Dewey Square)			
-- North Crosswalk	1,452	1,214	1,168
-- South Crosswalk	1,654	1,428	2,540
-- East Crosswalk	1,022	314	539
-- West Crosswalk	1,843	269	1,215
Summer Street/High Street/South Street			
-- North Crosswalk	1,133	1,403	842
-- South Crosswalk	740	1,195	1,008
-- East Crosswalk	401	203	114
-- West Crosswalk	195	497	169
Summer Street/Bedford Street/Lincoln Street			
-- East Crosswalk	321	604	341
-- South Crosswalk	519	962	853
Summer Street/ Devonshire Street			
-- North Crosswalk	1,616	3,479	1,823
-- South Side of Street	737	1,138	1,190

The volumes given in Table 4.4.2 are based on flow counts conducted in July 1983. More recent counts were conducted as part of this study. These counts were lower than the earlier counts and showed differences in crossing patterns. Because of the extensive construction in the area, the earlier counts were used as they are more likely to be reflective of pedestrian movements in the area without construction disruptions.

PUBLIC TRANSPORTATION SYSTEM

The proposed project is well served by public transportation. Figure 4.4.7 illustrates the major components of the system in

Location of Public Transportation

LEGEND:

Site

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SCALE: 1"=400'

Fig. 4.4.7

the vicinity of the project and their distances from the site. Because of the proximity of the site to the rapid transit system, a significant emphasis has been placed on rapid transit system capacity and ridership.

Rapid Transit

Direct access to all four rapid transit lines is available within walking distance of the site. South Station is two blocks to the east and provides access to the Red Line. Washington Station, whose nearest entrance is two blocks northwest of the site along Summer Street, is served by both the Red and Orange Lines. The Orange Line is also available at Essex, five blocks southwest of the site. The Green Line is available at Park Street Station, approximately one-third of a mile northwest of the site. It can be reached via an underground concourse which connects to the Washington Station entrance described above. Blue Line service is available at the State Station, whose nearest entrance is approximately one-third of a mile to the north.

Estimates of current ridership and line capacities are shown in Tables 4.4.3 and 4.4.4. All ridership and capacity figures are for the outbound direction in the PM peak hour. Total line capacity figures are based on a planning capacity for each car provided by the MBTA. Loads in excess of these planning capacities are possible and have been frequently observed. Consistent loading above the planning capacity provides an indication that additional capacity would be desirable in order to maintain comfortable and reliable service.

Line capacity is also based on the number of cars per train and the number of trains per hour. For the Green Line East, Orange Line and Blue Line, these factors were based on data and

TABLE 4.4.3
EXISTING RAPID TRANSIT LINE CAPACITY
PM PEAK HOUR OUTBOUND

Line/Segment	Average Cars/ Train	Average Headway* (minutes)	Average No. of Trains	Car Capacity**	Line Capacity
Red Line/North					
Ashmont-Alewife Braintree-Alewife	4	4	15	180	10,800***
Red Line/South					
Alewife-Ashmont Alewife-Braintree Park-Quincy	4	3.75	16	180	11,520
Green Line/West					
Boston College Cleveland Circle Riverside Huntington Avenue	1.6+	1.67	36	130	7,500
Green Line/North					
Lechmere service	1.33+	4	15	130	2,600
Orange Line/ North-South					
Oak Grove- Forest Hills	4	4	15	155	9,300
Blue Line					
Bowdoin-Wonderland	4	4	15	110	6,600

* Red and Green Line headways are based on observed system performance in fall 1986. Orange and Blue Line headways are based on schedules obtained from the MBTA.

** The MBTA uses these capacity estimates for planning purposes. Heavier loads can be carried and are often observed on the system.

*** Capacity is slightly lower than Red Line south because the Quincy-Park run is not included.

\+ Represents one-car trains on the Huntington Avenue Line and a mix of one and two-car trains on all other lines.

TABLE 4.4.4
EXISTING RAPID TRANSIT RIDERSHIP
PM PEAK HOUR OUTBOUND

Line/Segment	Peak Station	Existing Ridership*	Line Capacity for Each Direction**
Red Line/North Ashmont-Alewife Braintree-Alewife	Charles	7,140	10,800
Red Line/South Alewife-Ashmont Alewife-Braintree Park-Quincy	Andrew	11,190	11,520
Green Line/West Cleveland Circle Boston College Riverside Huntington Avenue	Arlington	10,000	7,500
Green Line/North Lechmere Service	Science Park	1,100	2,600
Orange Line/North Forest Hills- Oak Grove	North Station	10,270	9,300
Orange Line/South Oak Grove- Forest Hills	Essex	7,080	9,300
Blue Line/North Bowdoin-Wonderland	Aquarium	6,120	6,600

* Red Line and Green Line west ridership figures are based on independent observations in fall 1986; other ridership figures are based on 1984 MBTA counts.
** See Table 4.4.3.

schedules furnished by the MBTA. For the Red Line and Green Line west, these data were based on observations of transit performance made by Vanasse/Hangen over a two-week period in late September and early October 1986. Also included in those observations were recordings of passenger loadings.

As shown to Table 4.4.4, the south branch of the Red Line is currently operating at slightly less than its planning capacity. It is carrying approximately 11,200 passengers in the peak direction through Andrew Station (the peak load point for the south branch). Planning capacity is 11,500 based on existing observed headways. The Orange Line north is also carrying loads in excess of its planning capacity, with 10,300 passengers and a capacity of 9,300. The Green Line west ridership of 10,000 is well in excess of its capacity of 7,500 (based on existing observed headways).

Bus Service

The area is well served by commuter bus, with MBTA express service provided to the Financial District (along Federal Street) from the west. Private commuter bus service is provided at South Station. MBTA express bus service to the north is provided at the Haymarket station which can be reached via the Orange Line. These commuter bus lines are well used and it is the MBTA's policy to encourage continued use by minimizing standees. Consequently, the MBTA will add buses as demand warrants.

Commuter Rail

Commuter rail service to the south and west is provided within a few blocks of the site at South Station. Service to the north and northwest is provided at North Station, which can be

reached via the Orange Line. As a result, all commuter rail service is accessible from the project site.

PARKING

Public parking within the Financial District and South Station area is limited. The major garage facilities within the project area include Post Office Square (950 spaces), Kingston/ Bedford (735 spaces), Devonshire Street (900 spaces), One Post Office Square (400 spaces), and Beach Street (350 spaces). With the recent loss of major facilities at Fort Hill Square and on High Street, parking demand within the area is currently at or near the capacity of many of the remaining major facilities. In addition, the city is in the process of selling the Kingston/ Bedford garage for redevelopment. This will result in the elimination of those spaces. Short-term on-street parking is fully utilized by mid-morning according to counts taken in 1982 and reported in Parking in Central Boston.

4.4.3 PROBABLE PROJECT IMPACTS

DAILY TRIP GENERATION

In order to assess the impact of the project on the transportation system in the site area, travel demand by type of use and user has been estimated. The procedures used in estimating these trips consisted of calculating person-trips per 1,000 square feet of floor space. Trip rates and modal splits have been categorized as office vs. retail and work vs. non-work. Rates used in the calculations are identical to those used in the Final Environmental Assessment for 99 State Street (now called 75 State Street) and the Final Environmental Impact Report for International Place.

The development plan for 125 Summer Street calls for 482,000 square feet of office space and 13,000 square feet of retail space. Tables 4.4.5 and 4.4.6 summarize trip rates and modal splits assumed in the analysis and the resultant person-trips based on the proposed development plan.

TABLE 4.4.5
DAILY PERSON-TRIPS

User	Office			Retail Use		
	In	Out	Total	In	Out	Total
Generation Rates*						
Worker	4.40	4.40	8.80	2.75	2.75	5.50
Non-Worker	2.35	2.35	4.70	16.40	16.40	32.80
Total	6.75	6.75	13.50	19.15	19.15	38.30
Generated Trips**						
Worker	2,121	2,121	4,242	36	36	72
Non-Worker	1,133	1,133	2,266	213	213	426
Total	3,254	3,254	6,508	249	249	498

* Person trips per 1,000 square feet
** Total trips per day

TABLE 4.4.6
MODE SPLIT*

User	Office Use			Retail Use		
	Auto	Transit	Walk	Auto	Transit	Walk
Percentages						
Worker	30.0	70.0	0.0	30.0	70.0	0.0
Non-Worker	27.5	57.5	15.0	27.5	32.5	40.0
Total Person-Trips						
Worker	1,273	2,969	0	22	50	0
Non-Worker	623	1,303	340	117	139	170

* The mode split factors are based on data contained within the December, 1983 report, Parking in Central Boston: Meeting the Access Needs of a Growing Downtown. The parking study reports that, according to a 1980 survey, the Blue Cross/Blue Shield building at 100 Summer Street had 28.2 percent of its trips arrive by automobile. The non-work trip automobile factor is based on modal split assumptions used by the report for the area of downtown in which the project is located.

Table 4.4.7 summarizes anticipated vehicle occupancy rates for those trips arriving by auto. These rates are based primarily on information reported in Parking in Central Boston.

TABLE 4.4.7
VEHICLE OCCUPANCY FACTORS

Trip Type	Use	
	Office	Retail
Work	1.8	1.4
Non-Work	1.4	1.9

Applying the occupancy rates given in Table 4.4.7 to the person-trips arriving by auto projected in Table 4.4.6 results in a total estimate of 1,230 daily vehicle-trips (Table 4.4.8). These are distributed equally to inbound and outbound trips (615

each way). The 1,230 daily vehicle-trips include employee-related trips, visitors, taxis, and delivery vehicles. Refinement of the 1,230 trips to estimate taxi and delivery use suggests 34 taxi-related trips (3 percent of office non-employee arrivals as described in the Marketplace Center EIR) and 124 delivery-related trips (0.25 trips per 1,000 square feet as described in the International Place EIR).

TABLE 4.4.8
DAILY VEHICLE TRIPS

Trip Type	Use		
	Office	Retail	Total
Work	707	16	723
Non-Work	445	62	507
Total	1,152	78	1,230

PEAK HOUR TRIP GENERATION

Of greater concern than the total daily trips is the number of trips occurring during the peak commuter hours. It is these peak periods which are used to evaluate the performance of the transportation system. The peak hour percentages shown in Table 4.4.9 were multiplied by one-half (to reflect directional travel) of the daily trips in Tables 6 and 8 to obtain the results shown in Table 4.4.10. A total of 217 vehicle-trips is projected for the morning peak hour, while 223 trips are projected for the evening peak.

TABLE 4.4.9
PERCENTAGES OF DAILY TRIPS
DURING PEAK HOURS BY TYPE AND DIRECTION*

	Work		Non-Work	
	AM	PM	AM	PM
Office				
Arrivals	55%	0%	10%	0%
Departures	0%	55%	0%	10%
Retail				
Arrivals	10%	10%	0%	5%
Departures	0%	20%	0%	10%

* From International Place EIR

TABLE 4.4.10
PROJECT PEAK HOUR TRIPS BY MODE

	AM			PM		
	Auto*	Transit**	Walk**	Auto*	Transit**	Walk**
Office						
Work	194	816	0	194	816	0
Non-Work	22	65	17	22	65	17
Retail						
Work	1	2	0	2	7	0
Non-Work	0	0	0	5	10	13
Total	217	883	17	223	898	30

* Vehicle trips
** Person trips

The peak hour trips generated above represent the total number of trips generated by the site when it is fully developed as proposed. These trips also represent net new trips on area roadways because the existing buildings on the site are empty and are not generating any current trips to the site. Although the site was active at the time the base network volumes were developed, it was estimated that the traffic generated was not great.

Therefore, it was decided to use a conservative approach and assume that all trips generated by the development would represent new trips to the site.

TRIP DISTRIBUTION AND ASSIGNMENT

The vehicle-trips generated by the proposed development were distributed to the transportation system according to the trip distribution pattern listed in Table 4.4.11 and shown in Figure 4.4.8. This is the same pattern that has been established in other major downtown EIRs. Assignment of these trips to the local street system in the vicinity of the site was a function of the access to the proposed garage, the existing pattern of one-way streets in the vicinity and the location of Central Artery ramps.

TABLE 4.4.11
TRIP DISTRIBUTION

Direction	Percent
Northeast	14%
North	14%
Northwest	9%
West	17%
Southwest	22%
Southeast	24%
Total	100%

BACKGROUND TRAFFIC GROWTH

In order to assess future conditions, it is not only necessary to project development-related traffic increases, but also to project increases in background traffic. Growth in background traffic is a function of other development activity expected within the area. This growth can be projected by the application

LEGEND:

Site

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SCALE: 1"=400'

Trip Distribution Map

Fig. 4.4.8

of a generalized growth factor or by the assessment of specific development proposals. For this analysis, the projection of background or No-Build traffic (i.e., future traffic without the 125 Summer Street development proposal) was based on the assessment of other specific development proposals projected to be completed by 1989. This analysis year was used because the proposed 125 Summer Street development is expected to be completed in late 1988 and occupied in 1989.

Table 4.4.12 lists the projects included in the development of the 1989 No-Build networks. The table includes the projected uses for each development. The trip generation assumptions described earlier were applied against the projected uses for each identified background development to obtain projected vehicle, transit and pedestrian trips. The vehicle-trips were assigned to the roadways to obtain the morning and evening peak hour No-Build networks shown in Figures 4.4.9 and 4.4.10, respectively. The projected traffic from the 125 Summer Street development was added to these 1989 No-Build volumes to obtain the 1989 Build volumes shown in Figures 4.4.11 and 4.4.12.

It should be noted that the development plans for the Bedford Street garage site and the Lincoln Street/Essex Street site near the project site are uncertain at this time, but that the BRA does not anticipate redevelopment to be finished before 1990. Redevelopment of South Station was also considered in developing background volumes. By 1989, it is anticipated that the head-house will be completed, providing in excess of 100,000 square feet of office and retail space. In addition, the refurbishing of the train concourse and loading platforms should be complete. A 600-space garage and bus terminal will be completed at a later date. The base volumes used for this analysis from the Dewey Square report cited earlier include traffic from a former parking area at South Station that is no longer operational. Because the

base volumes already include South Station traffic, no additional traffic was generated for the reconstruction due to be completed by 1989.

TABLE 4.4.12
1989 BACKGROUND DEVELOPMENT

Development	Size	Use
99 Summer Street	293,500 SF*	Office
	9,500 SF	Retail
101 Arch Street	340,000 SF	Office
	46,000 SF	Retail
150 Federal Street	475,000 SF	Office
	10,000 SF	Retail
101 Federal Street	469,500 SF	Office
	15,000 SF	Retail
International Place	1,700,000 SF	Office
	100,000 SF	Retail
Rowes Wharf	665,000 SF	Office/Retail/ Residential
South Station	75,000 SF	Office
	35,000 SF	Retail
		Train Concourse/ Platforms

* SF - square feet.

The No-Build and Build networks assume the relocation of the High Street Central Artery off-ramp to Purchase Street, as outlined in the International Place EIR. The future networks, however, do not include the depression of the Central Artery, as that project would not be completed until sometime well after 1989.

INTERSECTION ANALYSIS

Traffic Operations Measures

Level of service (LOS) is a term used to denote the operating conditions on a roadway and is qualitatively measured as the effect of speed, delay, freedom to maneuver and safety. At Level of Service "A", the intersection operates at free-flow conditions. Typically, the intersection approach appears quite open and turning movements are made easily. Seldom, if ever, does a driver have to wait through more than one red signal indication.

Capacity of the intersection occurs at Level of Service "E" and is characterized by consistent backups or queues of vehicles waiting to pass through the intersection. Capacity represents the maximum number of vehicles that can be processed during a given time frame. At capacity conditions, vehicles will always be waiting on approach roadways to use signal green time. In this situation, some motorists may experience significant delays. There are many intersections in the Boston metropolitan area which operate at capacity levels during peak demand periods.

The analysis of signalized intersections is based on the sum of critical volumes from each intersection approach and the ratio of this volume to capacity. The capacity is equal to the maximum sum of critical volumes associated with Level of Service "E". Basic level of service criteria are shown in Table 4.4.13. Level of Service "F" represents jammed conditions and is used for situations where volumes are in excess of capacity.

TABLE 4.4.13
LEVEL OF SERVICE CRITERIA
FOR SIGNALIZED INTERSECTIONS*

Level of Service	Maximum Sum of Critical Volumes: Two Phase	Three Phase	Four or More Phases	Typical Volume/ Capacity Ratio
A	900	855	825	0.00-0.60
B	1,050	1,000	965	0.60.70
C	1,200	1,140	1,100	0.70.80
D	1,350	1,275	1,225	0.80.90
E	1,500	1,425	1,375	0.91.00
F	- - -	Not Applicable	- - -	Varies

* Transportation Research Board, Transportation Research Circular Number 212, Interim Materials on Highway Capacity, Washington, D.C., January, 1980 (Planning Criteria).

In capacity calculations for unsignalized intersections, the assumption is made that major street movement is not effected by minor street movement and that the capacity is a function of turns within the intersection and gaps in the through traffic stream. The difference between available capacity and existing demand is defined as reserve capacity and is used as the criterion for determining level of service. Table 4.4.14 summarizes the relationship between level of service, reserve capacity and expected traffic delay.

Capacity Analysis

All study intersections were analyzed using the signalized intersection analysis procedure described above. Table 4.4.15 and Figure 4.4.13 summarize the results of the capacity analysis for all intersections for Existing, No-Build and Build conditions. For all but one study intersection, the critical-volume criteria were reduced by the percent of cycle time allocated to exclusive pedestrian phases or by the estimated percent of green

TABLE 4.4.15
INTERSECTION LEVEL OF SERVICE SUMMARY

Location	Existing				1989 No-Build				1989 Build			
	AM		PM		AM		PM		AM		PM	
	V/C*	LOS**	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS
1. Congress St./High St.	0.48	A	0.57	A	0.60	A	0.64	B	0.60	A	0.64	B
2. Congress St./Purchase St.	0.80	C	0.92	E	0.80	C	1.32	F	0.80	C	1.32	F
3. Congress St./Atlantic Ave.	0.83	D	0.89	D	0.83	D	1.02	F	0.83	D	1.04	F
4. Federal St./High St.	0.66	B	0.50	A	0.78	C	0.52	A	0.78	C	0.54	A
5. Kneeland St./Surface Artery/ S.E. Expressway Ramp	0.85	D	1.07***	F	0.85	D	1.16	F	0.85	D	1.20	F
6. Kneeland St./Lincoln St./ S.E. Expressway Ramp	0.71	C	0.46	A	0.81	D	0.46	A	0.86	D	0.46	A
7. Kneeland St./Atlantic Ave./ Turnpike Ramp	0.54	A	0.33	A	0.56	A	0.33	A	0.57	A	0.33	A
8. Summer St./Lincoln St./ Bedford St.	0.57	A	0.46	A	0.71	C	0.51	A	0.71	C	0.63	B
9. Summer St./South St./ High St.	0.40	A	0.56	A	0.47	A	0.60	A	0.47	A	0.80	C
10. Summer St./Surface Artery/ Purchase St.	0.65	B	0.62	B	0.65	B	0.62	B	0.65	B	0.62	B
11. Summmer St./Atlantic Ave.	1.09***	F	1.01***	F	1.09	F	1.06	F	1.09	F	1.12	F
12. Surface Artery/Essex St./ Lincoln St.	0.80	C	0.68	B	0.90	D	0.70	B	0.97	E	0.74	C
13. Surface Artery/South St./ Expressway Ramp	0.61	B	0.73	C	0.66	B	0.76	C	0.67	B	0.88	D

* Volume-to-capacity ratio.
** Level of Service.
*** Existing volumes in excess of capacity result in part from the use of estimated volumes. In addition, the capacity numbers used in the intersection analyses represent generalized capacities. Capacity at a particular intersection may actually be higher depending upon actual operating characteristics.

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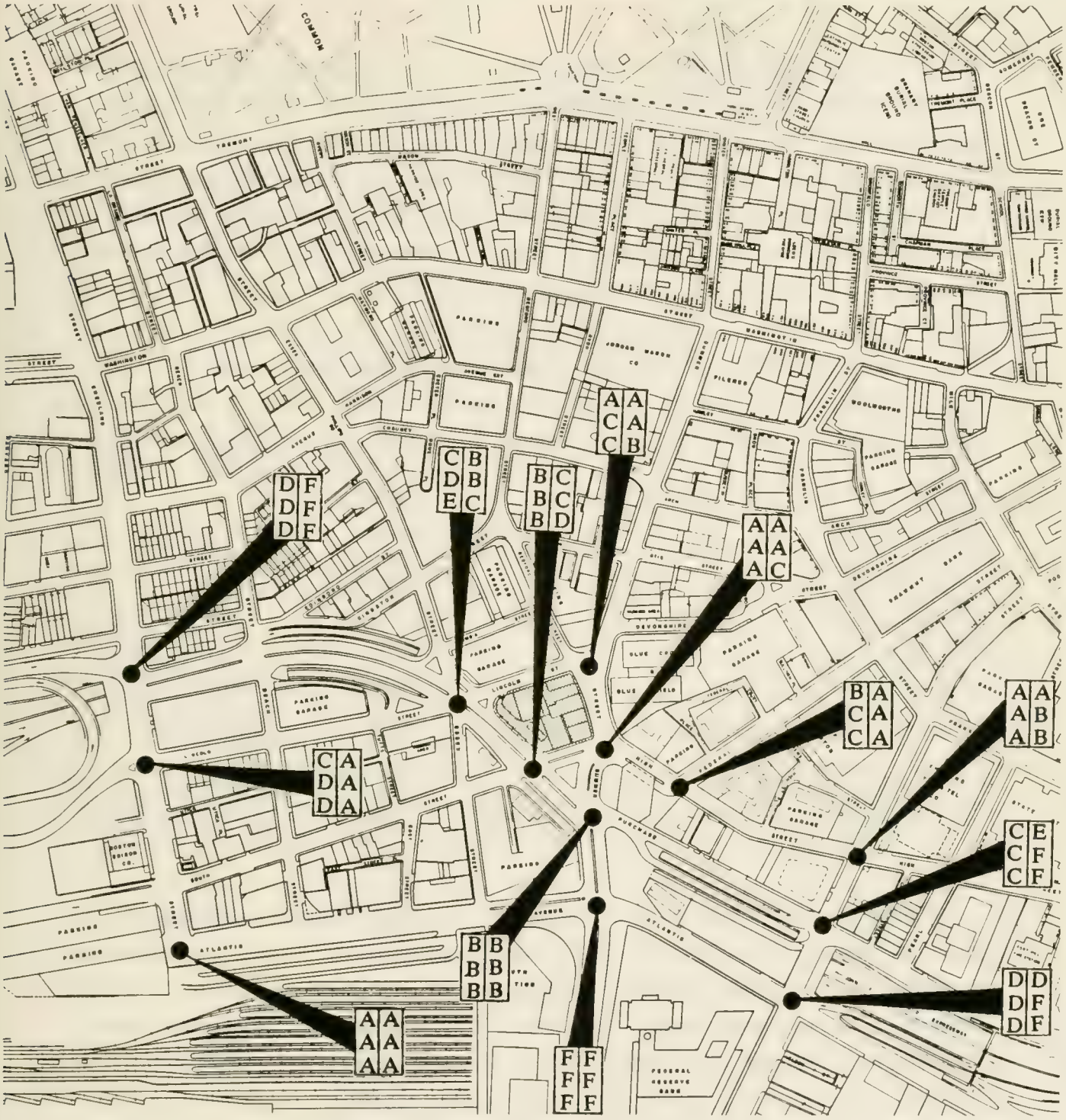

Intersection Level of Service

LEGEND:

AM/PM

X X Existing
X X No-Build
X X Build

SITE

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Scale: 1" =400'

Fig. 4.4.13

time lost by pedestrian interference (i.e., pedestrians walking against the "Don't Walk" signal or pedestrians caught in the crosswalk during the change to green). Due to the observation of relatively low pedestrian volumes at the Kneeland Street/Atlantic Avenue/ Massachusetts Turnpike off-ramp intersection, no reduction in the critical-volume criterion was made at this location.

TABLE 4.4.14
LEVEL OF SERVICE CRITERIA
FOR UNSIGNALIZED INTERSECTIONS*

Reserve Capacity	Level of Service	Expected Traffic Delay
400 or more	A	Little or no delay
300 to 399	B	Short traffic delays
200 to 299	C	Average traffic delays
100 to 199	D	Long traffic delays
0 to 99	E	Very long traffic delays
Less than 0	E	Failure-extreme congestion
(Any Value)	F	Intersection blocked by external causes

* Transportation Research Board, Transportation Research Circular Number 281, Proposed Chapters for the 1985 Highway Capacity Manual, Washington, D.C., June 1984.

Currently, three of the study locations operate at Level of Service (LOS) "E" or "F". The intersection of Kneeland Street, Surface Artery and Southeast Expressway ramp operates at LOS "F" in the evening peak hour, but LOS "D" in the morning peak hour. The Summer Street/Atlantic Avenue intersection operates at LOS "F" in both the morning and evening peak hours, and the intersection of Congress Street and Purchase Street operates at LOS "E" in the evening. All other locations operate at LOS "D" or better in both peak hours.

It should be noted that numerous ongoing construction projects in the area may be causing poorer levels of service at some locations than are indicated in Table 4.4.15. The levels of service shown are representative of base conditions in the study area without disruptions for temporary construction projects. At some locations, construction activity restricts the number of lanes available for traffic, resulting in increased congestion and reduced levels of service. At other locations, where there is no construction activity, there may be additional traffic as a result of drivers avoiding construction areas. This additional traffic results in increased congestion and reduced levels of service at these locations.

Table 4.4.15 also illustrates changes in volume-to-capacity ratios and levels of service under No-Build conditions in 1989. Seven of the 13 intersections analyzed experience a decline in level of service; however, all but one of these continue to provide LOS "D" or better in both morning and evening peak hours. In the evening peak hour, the Congress Street intersection at Purchase Street declines from LOS "E" to LOS "F", while the Congress Street/Atlantic Avenue intersection declines from LOS "D" to LOS "F".

The addition of project-related traffic to 1989 No-Build volumes results in four locations experiencing a change in level of service from No-Build conditions. Only one of these changes increases the number of intersections operating at LOS "E" or "F". The Surface Artery/Essex Street/Lincoln Street intersection will experience a decline from LOS "D" to LOS "E" in the morning peak hour.

At the four intersections projected to operate at LOS "F" under 1989 No-Build volumes, the addition of project traffic will have limited or no impact on volume-to-capacity (V/C) ratios.

The largest increase in V/C ratio will be at the Summer Street/ Atlantic Avenue intersection where the evening peak hour V/C ratio will increase by 0.06. The smallest increase will be at the Congress Street/Atlantic Avenue intersection where an increase of 0.02 in the evening V/C ratio will be experienced. There will be no change in V/C ratio at the Congress Street/ Purchase Street intersection.

In terms of actual volume, the largest project impacts would be at the Surface Artery/Essex Street/Lincoln Street intersection in the morning peak hour and at the Summer Street/Lincoln Street/ Bedford Street intersection in the evening peak hour. In the morning, the project will add an estimated 218 additional vehicles through the Surface Artery/Essex Street/Lincoln Street intersection. In the evening, the project will add an estimated 222 vehicles to the intersection of Summer Street/Lincoln Street/ Bedford Street. Only the additional morning volumes at the Surface Artery/Essex Street/Lincoln Street intersection will have a significant impact on delay and congestion at these locations.

The City is currently in the process of reviewing plans providing for the optimization of approximately 250 traffic signals in the Downtown area. The center of this program involves the installation of a computer to monitor traffic flow and select appropriate traffic signal phasing and timing based on demand. The computer portion of the program has been bid by the Massachusetts Department of Public Works with the local intersection improvements expected to be bid within several months. Completion of the work is expected by the time of full occupancy of the proposed 125 Summer Street development. This improvement program is expected to have a major impact on improving operations at individual intersections and throughout the system.

IMPACTS OF OTHER TRANSPORTATION PROJECTS

This section is designed to consider impacts of project related traffic on the roadway networks if any of several major roadway improvements should be implemented. Four such sets of improvements have been considered. These include Alternatives A and B from the Dewey Square Comprehensive Transportation Systems Management (TSM) Program, proposed access improvements to South Boston across the Fort Point Channel, and the Depressed Central Artery.

Dewey Square TSM Alternative A

The primary changes envisioned for Alternative A for the Dewey Square Program include making the Surface Artery one-way southbound and making Essex Street two-way between Atlantic Avenue and Kingston Street. This system would not result in any changes in routes to and from the site. Inbound traffic would continue to approach the site along Essex Street, South Street and Surface Artery (from the north), while outbound traffic would use Federal Street, Summer Street and Atlantic Avenue, and Surface Artery.

Dewey Square TSM Alternative B

Alternative B is similar to Alternative A, but with some additional changes. These changes include making High Street one-way northbound between Summer Street and Atlantic Avenue; making Summer Street one-way eastbound between Lincoln and High Street; eliminating the short eastbound segment of Summer Street between High Street and Purchase Street; and closing South Street between Summer Street and the Surface Artery. Alternative B would have no effect on most travel paths to or from the site except for outbound traffic to the south and west (Southeast

Expressway and Massachusetts Turnpike) and to the north. Because of the closure of South Street next to the site and the elimination of the eastbound segment of Summer Street between High and Purchase Streets, all outbound traffic to the north and south would have to travel north on High Street to Congress Street where vehicles would turn right. Proceeding on Congress Street to Purchase Street, southbound traffic would turn onto the southbound Central Artery ramp. Northbound traffic would proceed straight across Purchase Street and turn left onto the northbound Central Artery ramp at Atlantic Avenue.

The Alternative B circulation pattern would eliminate expected evening peak hour project impacts along the Surface Artery, at the Purchase Street/South Street/Summer Street intersection, and at the Summer Street/Atlantic Avenue intersection. Project impacts would be increased at High Street and Federal Street, High Street and Congress Street, and Congress Street and Purchase Street.

South Boston Access

The major improvement in South Boston access across the Fort Point channel which could occur by 1989 would be the replacement and relocation of the Northern Avenue Bridge. Although this improvement will result in better and more reliable access to South Boston, it will have little impact on conditions at study area intersections. The only impact on the project will be somewhat improved access for traffic to and from South Boston.

A more significant improvement in terms of impact on downtown locations is a proposed people mover between South Station and the World Trade Center. Such an improvement may serve to generally remove traffic from downtown streets and thereby contribute to improved operating conditions. This proposal is

still in the early planning stages and an evaluation at this point is infeasible. It would likely not be fully operational until well after the study year for the 125 Summer Street project.

Depressed Central Artery

The potential impact of the depressed Central Artery is based on the Modified 5A design presented in the Final EIS for the Third Harbor Tunnel/Central Artery project. The major features of that design with regard to study area roadways are making the Surface Artery one-way between Summer Street and Kneeland Street (similar to the Dewey Square TSM improvements); making the Central Artery's South Station tunnel one-way southbound except for one contra-flow lane northbound which would begin at Essex Street; and moving the northbound Central Artery to a new tunnel under the Fort Point Channel. Inbound and outbound routes to the site would remain essentially the same as those that would be used with the current roadway network. Under the most optimistic circumstances the depressed Central Artery would not be completed for several years following the completion of 125 Summer Street.

TRANSIT AND PEDESTRIAN ANALYSIS

Rapid Transit

The proposed project is expected to generate approximately 894 outbound transit trips in the evening peak hour. Based on the 1982 Cordon Count for Downtown Boston, 70 percent of transit trips are made by rapid transit. Therefore, a total 626 outbound rapid transit trips can be expected to be generated by the proposed development. As described earlier, a considerable level of background growth due to other area development is also anticipated. The assignment of background transit trips and

project transit trips are shown in Table 4.4.16. This assignment is based on each line's share of total rapid transit ridership in 1984.

Passengers on the Green Line are expected to walk directly to Park Street to board, while Orange Line passengers, as well as northbound commuter bus and commuter rail riders, will board at Washington. Orange Line passengers may also use Essex station, but were all assumed to use Washington in order to be conservative in projecting pedestrian volumes along Summer Street. All southbound Red Line commuters are expected to use South Station. Because the site is located closer to South Station than Washington Street, 50 percent of Red Line northbound passengers were assumed to use South Station while the other 50 percent of northbound passengers would use Washington. Blue Line passengers were forecast to use the Orange Line at Washington and transfer at State, although some would probably walk directly to State.

TABLE 4.4.16
ASSIGNMENT OF RAPID TRANSIT TRIPS
GENERATED BY PROJECT AND BACKGROUND DEVELOPMENT
PM PEAK HOUR

Line/Direction	Percent Distribution	Background Trips*	Project Trips	Total Trips
Red/North	12	1,348	75	1,423
Red/South	23	2,583	144	2,727
Blue/North	12	1,348	75	1,423
Orange/North	20	2,246	125	2,371
Orange/South	14	1,573	88	1,661
Green/West	17	1,909	106	2,015
Green/East	2	225	13	238
Total	100	11,232	626	11,858

* Transit trips generated by all downtown and South Boston background development. Also includes generalized growth factor to account for non-downtown development impacts.

Rapid Transit Improvements

A series of rapid transit improvements are underway with completion anticipated before 1989. These include relocation of the Orange Line and increased capacity on the Orange, Red and Green Lines.

The Southwest Corridor Project involves the expansion of trains from four to six cars and the relocation of the Orange Line south of Essex Station. The segment involved is approximately 4.7 miles in length and includes eight new stations.

Red Line improvements include platform lengthening, station modernization, acquisition of new cars, renovation of existing cars and track reconstruction. These improvements will allow the use of six-car trains resulting in a system capacity increase of 50 percent.

The Green Line is also scheduled for improvements to its vehicle fleet. One hundred new LRVs, scheduled for delivery by the end of 1987, will help alleviate current equipment shortages and improve system performance.

The projected future volumes and capacities with improvements in place are shown in Table 4.4.17. Under Build conditions, the Orange Line will operate just over planning capacity in the north direction and under capacity in the south direction during the evening peak hour based on six-car trains and somewhat longer headways. Under Build conditions, the Green Line west ridership would exceed planning capacity by 28 percent, compared with the present 33 percent overcapacity. With the planned expansion of the Red Line trains to six cars and the maintenance of existing headways, this line will operate under capacity. The Blue Line will is expected to exceed its planning capacity. Projected Build volumes generally represent about a 1.0 percent increase

TABLE 4.4.17
TRANSIT VOLUMES AND CAPACITIES
PM PEAK HOUR OUTBOUND

Line/Segment	Existing*	1989 No-Build Volume	1989 No-Build Percent Increase	1989 Build Volume	1989 Build Percent** Increase	Line Capacity***
Red Line/North Ashmont-Alewife Braintree-Alewife (Charles)	7,140	8,488	18.9	8,563	0.9	16,200
Red Line/South Alewife-Ashmont Alewife-Braintree Park-Quincy (Andrew)	11,190	13,873	24.0	14,017	1.0	17,280
Green Line/West Total of All Lines (Arlington)	10,000	11,910	19.1	12,016	0.9	9,630
Green Line/North Lechmere Service (Science Park)	1,100	1,325	20.4	1,338	1.0	2,600
Orange Line/North Forest Hills- Oak Grove (North Station)	10,270	12,516	21.9	12,641	1.0	12,400
Orange Line/South Oak Grove-Forest Hills (Essex)	7,080	8,654	22.2	8,742	1.0	12,400
Blue Line/North Bowdoin-Wonderland (Aquarium)	6,120	7,468	22.0	7,543	1.0	6,600

* All existing ridership figures are for the peak direction at the peak station (in parentheses) in the peak hour.

** Percent increase in 1989 Build vs. 1989 No-Build.

*** Projected Red Line capacity is based on six-car trains operating at existing observed headways. Orange Line capacity is based on six-car trains operating at slightly increased headways (4.5 minutes) based on current MBTA plans. Green Line west capacity is based on 36 two-car trains operting at the currently observed headways (100 seconds). The passenger capacity of each car is based on figures used by the MBTA for planning purposes. Heavier loads can be carried and are often observed on the system.

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over the No-Build volumes. In general, background volumes would generate about a 21 percent increase over existing volumes.

Express Bus

Almost one-quarter of the project-generated transit rider trips (206 in the evening peak hour) are expected to be by bus. Five express routes provide service between the Financial District and suburban areas along the Massachusetts Turnpike. Express bus service is also available from Haymarket to North Shore coastal communities. Private commuter bus service to the South Shore is provided at South Station. Local bus service is limited and has not been analyzed.

The extent of the service coupled with the level of new trips from the proposed development will result in minor impacts on express bus operation. The MBTA maintains a policy that reduces the potential for standees by releasing buses when seats are filled in order to maintain the high level of ridership. This includes adding buses to the express routes as needed.

Pedestrians

Most pedestrian trips will be transit related (i.e., walking to rapid transit stations or bus stops). Approximately 510 pedestrian trips a day are expected to be strictly walking trips (i.e., the entire trip is made by walking, and no other mode of travel is used for any portion of the trip). Only 30 walk trips are projected to occur in the evening peak hour. The majority of transit-related pedestrian trips can be expected to use Summer Street west of the site for access to the Washington and Park Street stations and Summer Street east of the site for access to South Station via Dewey Square. Blue line passengers were

assumed to use Summer Street to board at Washington and transfer at State, however, some may walk north up Devonshire Street to reach State Street directly.

Pedestrian volumes were analyzed along Summer Street to account for the project-generated pedestrian trips, as well as expected volumes from four other background development projects. These projects include 101 and 150 Federal Street, 99 Summer Street and 101 Arch Street (Franklin Place).

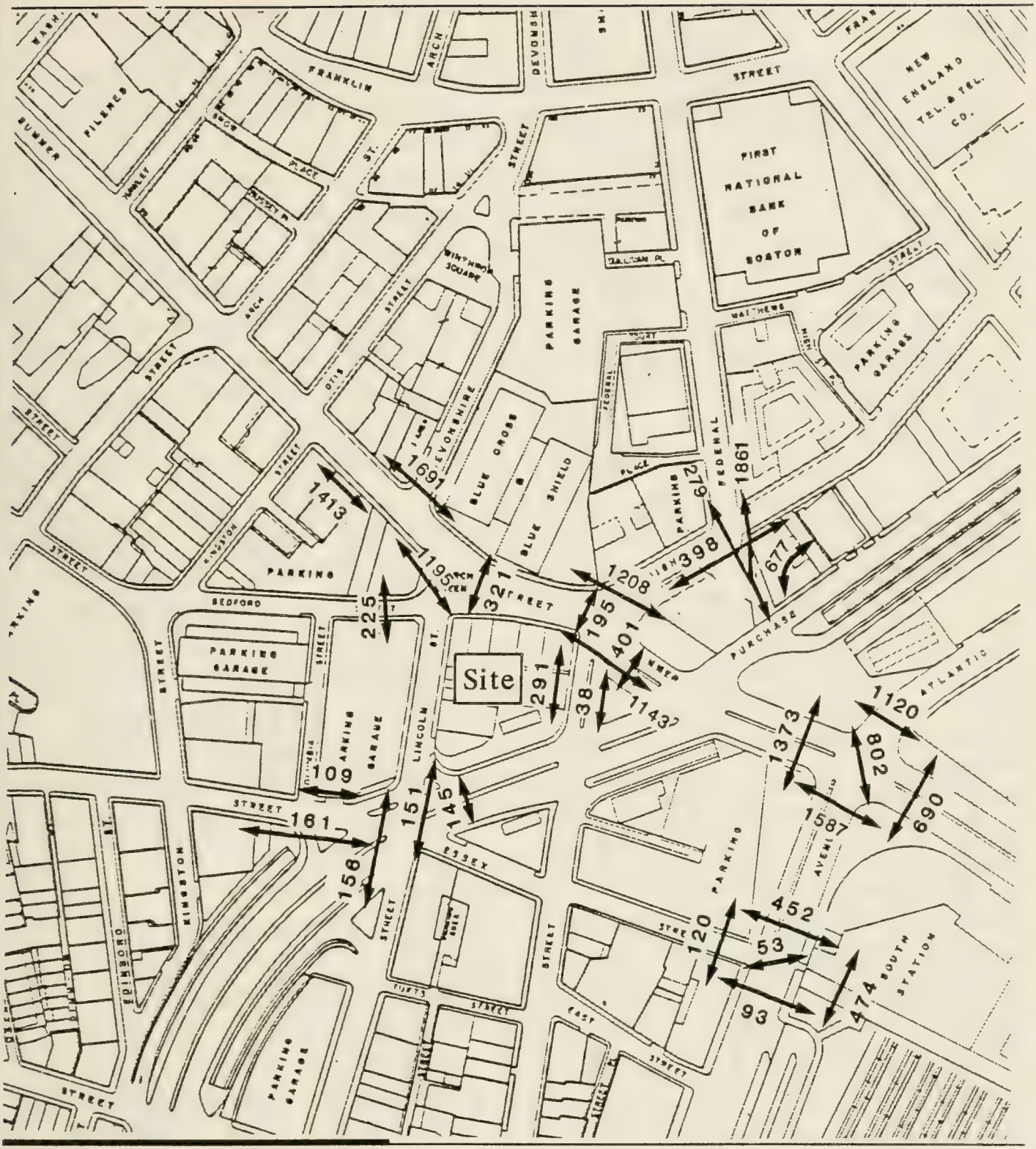
Table 4.4.18 shows project and background pedestrian volumes along Summer Street. The volumes are shown for peak load areas at the South Station and Washington transit stations. The project would generate almost 850 pedestrians along Summer Street in the PM peak hour. One-third of these (285) pedestrians would walk through Dewey Square to South Station, while the remainder (566) would walk toward Washington and Park Street stations. Most of these trips would be bound for either bus or transit stops. Figures 4.4.14 and 4.4.15 show total 1989 pedestrian volumes.

TABLE 4.4.18
SUMMER STREET PEDESTRIAN VOLUMES*

Direction	Background**	Project	Total
At Dewey Square	721	285	1,006
At Washington Street	2,027	566	2,593
Total	2,748	851	3,599

* Pedestrian volumes consist of all walk trips and transit-related pedestrian trips.
** Background projects included are: 101 and 150 Federal Street, 99 Summer Street, and 101 Arch Street.

Based on the volumes shown in Figures 4.4.14 and 4.4.15, a pedestrian level of service analysis was performed for the south side of Summer Street between South Street and Surface Artery.



1989
A.M. Peak Hour
Pedestrian Flows
7:30–8:30

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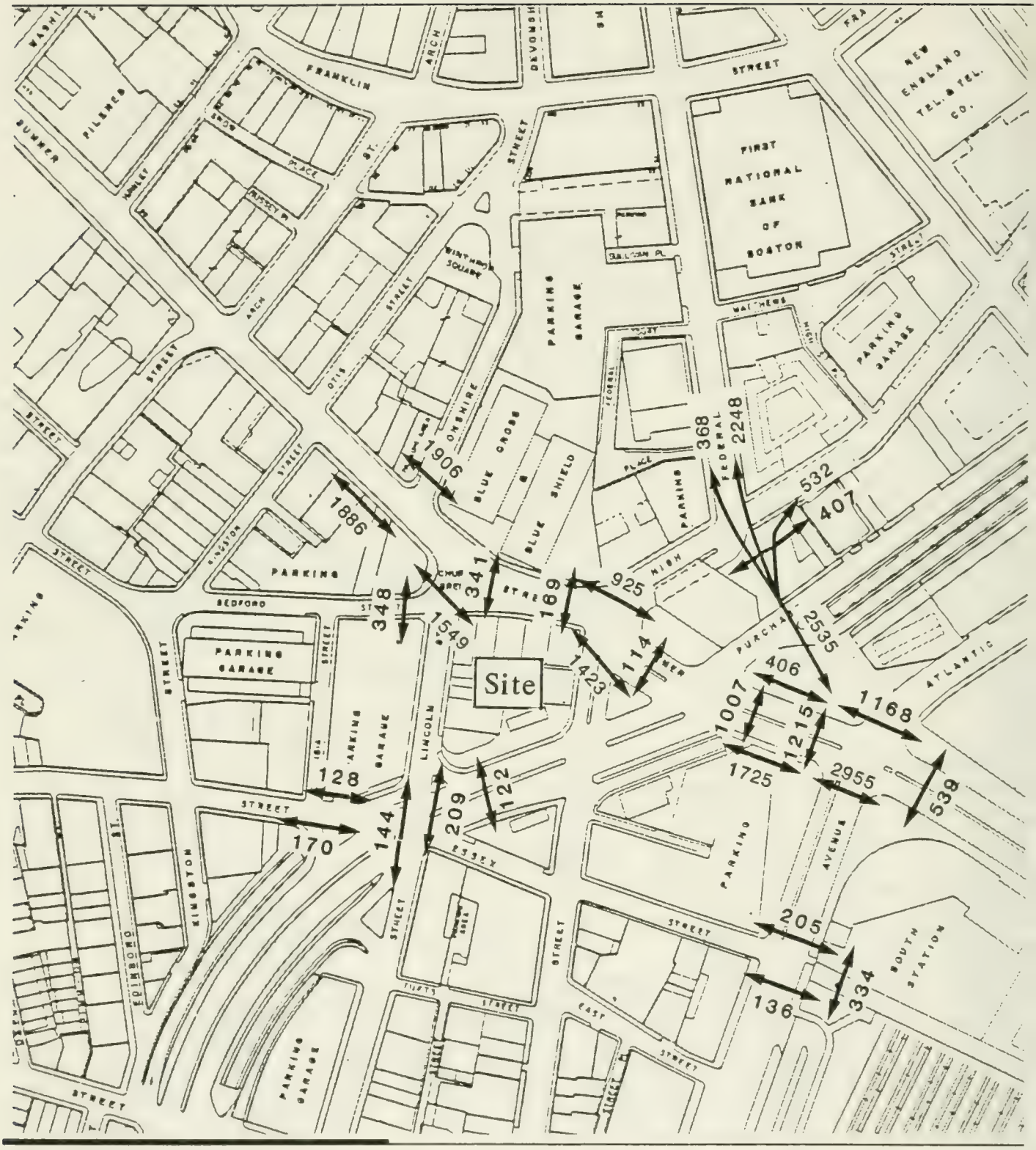
60 Birmingham Parkway, Boston, MA 02135

Scale: 1" =200'

Fig. 4.4.14



1989
P.M. Peak Hour
Pedestrian Flows
4:30–5:30

Vanasse/Hangen
Consulting Engineers & Planners
60 Burmingham Parkway, Boston, MA 02135

Scale: 1" = 200'

Fig. 4.4.15

This location was chosen because all pedestrians traveling between the project and Dewey Square are expected to use this block before entering the rapid transit station in front of One Financial Center or crossing Atlantic Avenue to reach commuter rail or commuter bus service. It also has the narrowest sidewalk location between the site and South Station. Using procedures outlined in the 1985 Highway Capacity Manual, it is expected that pedestrians will experience a Level of Service "B" in both the morning and evening peak hours. This is based on an effective sidewalk width of 8 feet.

PARKING

The 125 Summer Street development includes the provision of a maximum of 400 parking spaces. Access to the garage will be via an entrance on Lincoln Street. Admittance will be restricted to those individuals who have magnetic cards to gain access to the building. A card controlled gate and an access door (similar to the door located at the JFK Federal Building on Cambridge Street) will be provided. The doors will be recessed from the roadways a sufficient distance to hold one waiting vehicle (car or delivery truck) without it blocking the adjacent sidewalk or street.

A loading dock with three bays will also be provided inside the buildings with an entrance on Lincoln Street. The bays inside the building will have sufficient space for trucks to back into the bays once they have pulled forward to get inside the building. As a result, there will be no blockage of Lincoln Street traffic by trucks blocking of Lincoln Street traffic by trucks backing into the bays.

Parking Demand

The 495,000 square foot development will generate the need for 362 long-term employee spaces (all day commuter parking) based on trip generation factors previously detailed. These assumed that 30 percent of the building's employees arrive via auto with an occupancy rate of 1.8 persons per vehicle. The short-term demand from building visitors is approximately 95 spaces. This demand was calculated using a turnover rate of 2.67 cars per space per day taken from Parking in Central Boston. The turnover was applied to the number of non-work trips arriving at the site. Total daily parking demand will be 457 spaces.

Spaces in the garage will be allocated to tenants on the basis of the amount of space leased. As noted earlier, access to the garage will be controlled by card-operated gates and doors. As a result, the garage will serve only long-term tenant needs. In addition, because of the downtown parking freeze, no new commercial parking spaces may be added downtown. Therefore, the developer is unable to provide additional short-term parking. If the proposed maximum of 400 spaces is provided, all projected long-term needs will be accommodated. Provision of less than 362 spaces would result in a shortfall in the supply of long-term spaces versus projected demand. A shortfall of 95 short-term spaces (all short-term demand) is expected because the garage spaces are to be allocated for tenant (long-term) use only.

CONSTRUCTION IMPACTS

Construction Employee Trip Generation and Parking

The number of workers required over the two-year construction period will vary but it is estimated that the peak at any given time will not be more than 350 workers. Trip generation by

construction workers is a direct function of employment levels. Assuming an auto occupancy of two or three persons (based on the shortage of parking, current costs of parking and the greater inclination of construction workers to carpool), the 350 employees during the peak construction period would generate from 117 to 175 trips each peak period if all employees commute by automobile. In fact, the construction firm selected by the developers for this project estimates that at least half of the construction workers will likely utilize public transportation due to the downtown location of the site and its good accessibility via transit. In addition, construction workers generally travel before the peak hours (working 7:00 AM to 3:30 PM), so they do not add to commuter peak hour traffic. As a result, no significant impact to the area roadway system is anticipated from construction worker vehicle-trips.

No parking will be available on-site for construction workers. Therefore, the construction workers who drive will park in available public spaces in area garages or surface parking lots. This assumption is reasonable in light of the recently completed Copley Place development, a large project for which no construction parking arrangements were made. Some workers may park at surface lots along Northern Avenue across the Fort Point Channel because of the high daily cost of off-street parking in the immediate area. The project contractor indicates that these lots are commonly used by construction workers working in downtown. Alternatively, the high cost of downtown parking may encourage lower auto use and higher transit usage.

Street Closure

Although no materials storage area will be established on-site, areas on the periphery of the site will be used for unloading construction materials. State land adjacent to the

site near the Central Artery vent stack along the Surface Artery will be used as the main staging area, and a flip-down loading dock will be provided on Lincoln Street for materials which can be transported via the on-site hoist. No street closures will be required during project construction. The only lane restrictions that will be necessary include the Surface Artery curb lane from 6:00 AM to 3:30 PM (no blockage permitted during the afternoon commuter peak period) and the Lincoln Street curb lane during deliveries at the flip-down loading dock (no blockage permitted during the morning commuter peak period). No blockage of existing South Street or Summer Street travel lanes will be permitted.

As part of the project construction, the facades of existing buildings along Summer Street and the northern portions of Lincoln and South Streets are to be preserved. In order to accomplish this, a facade support system must be erected that will extend approximately 10 feet from the faces of the existing buildings. This will cover the sidewalk and extend slightly into the curb lane which is currently posted for no parking but is frequently used for illegal parking. Provisions will be made for pedestrian flow on Summer Street by means of a walkway adjacent to the facade support.

The exact source locations of construction materials are not known at this time, but it is estimated that all deliveries will access the site via the Surface Artery and Central Artery. Deliveries from the north are expected to exit the Central Artery at Purchase Street and proceed to the site via the Surface Artery. Deliveries from the west and south will exit the Turnpike and Southeast Expressway at Kneeland Street. Large trucks will proceed to the site via Atlantic Avenue, Summer Street and the Surface Artery so as to allow these vehicles to be properly lined up for entry into the construction material

delivery/pickup lanes to be provided at the site (see Construction Management section of "Access Plan"). Smaller trucks can use South Street to the site. Return trips to the north will be via the Atlantic Avenue on-ramp north of Congress Street, while southbound and westbound trips will use the Surface Artery to reach the Kneeland Street on-ramp.

4.4.4 ACCESS PLAN

DEMAND REDUCTION/MANAGEMENT STRATEGIES

Reducing the amount of traffic generated is an effective alternative to simply providing the roadway improvements necessary to satisfy projected traffic growth. Much can be done to reduce automobile usage and thereby lessen the need for improvements or provide for the more efficient use of any improvements provided. The following describe measures designed to reduce the number of vehicle-trips into the project area. All have been discussed with the proponent, who has committed to implementing them in so far as it is within his ability to do so.

Ridesharing

Ridesharing is an overall term that refers to encouraging commuters to ride in vehicles with other commuters rather than driving to work alone. The most common forms of ridesharing are carpools and vanpools. Increased ridesharing means that fewer vehicles will be using the roadways, with the result that there will be less congestion. An additional benefit will be reduced fuel consumption, as fewer vehicle miles will be traveled.

Carpooling and vanpooling programs are best implemented at the company level with a designated administrator to oversee the program. Incentives will include:

1. Provision of on-site carpool/vanpool matching programs;

2. Participation in joint programs with other nearby tenants organizations, and companies;

3. Provision of promotional materials on ridesharing to employees;

4. Publication of a building newsletter and a computerized billing system for tenants which will provide flexibility in disseminating information and aid in matching potential poolers;

5. Sponsorship of Caravan (an organization which leases commuter vans and provides administrative and organizational assistance) and other van leasing programs.

Public Transportation

Another major way to reduce the number of vehicles on the roadways is to encourage employees to use transit instead of driving to work. The proposed project site is located within walking distance of South Station, the Express Bus stops in the Financial District, and the Park Street (Green Line) and Washington Street (Red and Orange Lines) rapid transit stations. This provides an excellent opportunity for the project to generate high transit usage. The proponent will encourage transit usage through the following measures:

1. Provision of an on-site location for sale of MBTA passes and private bus line tickets;

2. Subsidization of a portion of the cost of MBTA passes or other weekly/monthly commutation tickets for the proponent's employees;

3. Encouraging other tenants to subsidize a portion of their employees' public transportation costs;

4. Provision of bus, commuter rail and commuter boat schedules;

5. Provision of promotional and informational materials for all forms of public transportation;

6. Working with the MBTA to provide an improved bus shelter and amenities within the project block.

Alternative Work Schedules

Alternative work schedules offer a way to reduce peak hour demands on the roadway system and on transit systems by shifting travel to non-peak hour periods or by reducing the total amount of travel per week. The major alternatives are:

a. Staggered work hours - are generally set up in such a way that groups of employees are assigned staggered starting times, typically at 15-minute intervals, spread over a one or two-hour period;

b. Flexible work hours - allows employees to choose their own starting and finishing times, as long as they are present during a central part of the day (called core time);

c. Compressed work weeks - involves shifting some workers from a standard five days per week, eight hours per day schedule to fewer days of longer hours (e.g., four days per week, ten hours per day).

The proponent has agreed to the following measures in this category:

1. Implementing one of the above concepts for its own employees;

2. Encouraging other tenants to do the same during the lease negotiation process;

3. As an incentive for other tenants, the proponent will make building services such as heat, air conditioning, etc., available during "off-hours" at no cost penalty if tenants shift employee start/end times.

Parking Supply Management

The development's parking supply will be managed to encourage reduced peak hour traffic. Measures which would accomplish this include:

1. Provision of one vanpool parking space for each 50,000 square feet of building space, or 10 vanpool spaces for the project;

2. Preferential parking for carpool and vanpool vehicles.

3. Construction of the project, particularly the creation of a new garage entrance on Lincoln Street, will not require the loss of any curb parking spaces due to the existing parking/stopping prohibitions on all four sides of the project block.

Delivery Vehicles

1. Restriction of all tenant delivery vehicles (with the exception of courier services) to off-peak hours, which include all times other than 7-10 AM and 3-6 PM.

2. Restriction of major tenant deliveries (which typically require the moving of furniture, etc.) to before 7:00 AM or after 6:00 PM;

3. Provision of a 24-hour loading dock attended by a full-time dockmaster to encourage off-hours deliveries;

4. Prohibition of any deliveries by tractor-trailer vehicles;

5. Prohibition of deliveries to the building from any location other than the loading dock. No deliveries will be accepted through the main entrances to the building.

6. Provision of sufficient off-street space for all delivery vehicles, including bicycles, to minimize on-street activity (all space will be drive-in/drive-out, requiring no backing);

7. Items 3 and 5 will reduce turnover time for delivery vehicles (dockmaster can jockey vehicles in loading area) and improve security for delivery services if they use the off-street facility;

8. Use of collection boxes for major courier services (Federal Express, Purolator, etc.) at a location convenient to the loading dock. Dropoffs/pickups will not be accepted at other locations, thereby minimizing impact on street traffic.

9. The loading dock entrance on Lincoln Street will not require the loss of any curb parking spaces due to the existing No Stopping regulations.

Taxis

1. Provision of a taxi stand waiting area on the project's Summer Street frontage near the Lincoln Street end to provide on-call pickups at the main building entrance. The stand would serve area wide needs since none are located in the immediate vicinity. Space for three taxis should be sufficient. No curb parking spaces will be lost due to the existing No Stopping regulations.

2. Taxi drop-offs would occur at any of the three building entrances on Lincoln, Summer or South Streets. Curb access will be available with the continuation of the existing No Stopping regulations on these block faces.

Pedestrians

Good pedestrian linkages should be available between the project and the main activity areas surrounding the site. Important connections include the following:

a. Across South Street and Surface Artery to One Financial Center and South Station,

b. Across Summer Street to 100 Summer Street, Devonshire Street and Downtown Crossing,

c. Across Lincoln Street to the proposed Bedford Building,

d. Along Surface Artery toward Essex Street and Chinatown.

Therefore, the following improvements are proposed to enhance existing pedestrian amenities in the project area:

1. Painted or rubble block crosswalks are provided at all intersections around the site in appropriate locations for the activity centers noted above. However, it would be desirable to renew the paint markings since many are worn.

2. All intersections surrounding the site except one are equipped with pedestrian actuation devices (push buttons) and Walk/Don't Walk signal indications these have been timed for existing traffic conditions in the Dewey Square area so as to allow concurrent pedestrian crossings and minimize undue delay to both vehicles and pedestrians. The one location which is not so equipped is Summer/ Lincoln/Bedford, which currently has only crosswalks. It is proposed that this intersection be investigated for the possible addition of pedestrian crossing signals. It is also proposed that all other locations around the site be evaluated for potential modifications to pedestrian signal timing and phasing.

3. Appropriate levels of street lighting will be provided on all sidewalks surrounding the site. Only the South Street block is currently equipped with lighting.

Other

1. Provision of a secure bicycle storage area for use by employees who wish to commute via bicycle.

2. Appointment by the project proponent of a staff person to coordinate all of the above efforts.

Access Goals

1. In the impact analysis section, figures were given for several factors which, when combined, resulted in the project's estimated contribution to vehicle trip and transit trip loadings on the study area transportation systems. Three such factors are the most significant in terms of this end result. They are:

   - Percent transit use (person trips to/from the project by all forms of public transportation)
   - Vehicle occupancy rate (number of people in each vehicle driving to/from the project)
   - Peak hour percentage (the portion of daily trips to/from the project which occur during the AM or PM peak hour)

   To minimize vehicular travel, it would be desirable if the first two factors were higher than assumed and the third factor lower than assumed. This serves as the basis for establishing a set of access goals for the project, as shown in Table 4.4.19. The table lists each of the three factors, or measures of effectiveness, along with the value estimated in the impact analysis, the Access Plan feature that will try to improve the factor, and the goal set for each factor after implementation of the Access Plan at full project buildout and occupancy. The lower portion of the table summarizes the AM and PM vehicle trips and transit person trips estimated for the original impact analysis factors and for the new factors which will be the goals. It should be noted that all figures in the table refer to office work trips, which constitute about 89 percent of the project's vehicle trip generation and about 93 percent of its transit trip generation.

TABLE 4.4.19
ACCESS GOALS

		Analysis Estimate	Mitigation Action	Goal
A. Trip Generation Factors				
Percent by Transit		70%	Transit Incentive	75%
Vehicle Occupancy Rate		1.8	Ridesharing	2.0
Peak Hour Percentage		55%	Alternative Work Hours	50%
B. Resulting Peak Hour Trips				
Vehicle Trips:	AM	194		133
	PM	194		133
Transit Trips:	AM	817		795
	PM	817		795

The impact of fulfillment of Access Plan goals on level of service is shown in Table 4.4.20. In the AM peak hour the greatest impact on V/C ratios would occur at Surface Artery/ Lincoln Street/Essex Street, where the Build V/C ratios would decline from 0.97 to 0.94. The only other change in the AM would be at Lincoln Street/Kneeland Street/Southeast Expressway Ramp, where the V/C ratio would decline from 0.86 to 0.84.

In the PM peak hour, six intersections would experience improved V/C ratios. The greatest impacts would occur at Summer Street/South Street/High Street, where the ratio would decline from 0.80 to 0.74, and at Surface Artery/South Street/Expressway Ramp, where the V/C ratio would decline from 0.88 to 0.84.

TABLE 4.4.20
EFFECTS OF ACCESS PLAN
GOALS ON VOLUME-TO-CAPACITY RATIOS

Location	AM Peak Hour		PM Peak Hour	
	Without Access Goals	With Access Goals	Without Access Goals	With Access Goals
1. Congress St./ High St.	0.60	0.60	0.64	0.64
2. Congress St./ Purchase St.	0.80	0.80	1.32	1.32
3. Congress St./ Atlantic Ave.	0.83	0.83	1.04	1.04
4. Federal St./ High St.	0.78	0.78	0.54	0.54
5. Kneeland St./ Surface Artery/ S.E. Expressway Ramp	0.85	0.85	1.20	1.18
6. Kneeland St./ Lincoln St./ S.E. Expressway Ramp	0.86	0.84	0.46	0.46
7. Kneeland St./Atlantic Ave./Turnpike Ramp	0.57	0.57	0.33	0.33
8. Summer St./Lincoln St./Bedford St.	0.71	0.71	0.63	0.62
9. Summer St./South St./High St.	0.47	0.47	0.80	0.74
10. Summer St./Surface Artery/Purchase St.	0.65	0.65	0.62	0.62
11. Summer St./ Atlantic Ave.	1.03	1.03	1.16	1.14
12. Surface Artery/ Essex St./ Lincoln St.	0.97	0.94	0.74	0.73
13. Surface Artery/ South St./ Expressway Ramp	0.67	0.67	0.88	0.84

2. As a follow up to the setting of goals, the proponent will provide annual management reports to the City on compliance with the stated objectives as well as other elements of the Access Plan.

3. The proponent also commits to work with the City to resolve any areas of non-compliance.

CONSTRUCTION MANAGMENT

An important component of the Access Plan is an effective series of measures designed to minimize traffic flow and safety impacts during the construction phase. Summarized below are several measures which will be incorporated into the construction management plan for the project. The details of the plan are included in a Traffic Maintenance Agreement which is included in the Appendix. The summary listing is as follows:

1. Secure fencing, staging and bracing around the entire block, including sidewalks, to protect pedestrian traffic near the construction site.

2. Use of the adjacent State land near the Central Artery vent stack on the Surface Artery side of the block as the main staging area for construction materials. A lane for soil removal trucks and concrete trucks will be provided through this area with separate in and out gates to reduce the need for backing of construction vehicles onto the Surface Artery.

3. Use of the adjacent curb lane on the Surface Artery for steel delivery trucks. This lane will be operated only from 6:00 AM to 3:30 PM so as not to disrupt the afternoon commuter peak hour. A removable barrier will

separate the lane from general traffic during its operation. The existing bus stop on this block will be relocated.

4. No blockage of existing travel lanes on Summer Street or South Street at any time.

5. Use of a narrow portion of Lincoln Street (approximately one lane wide) as a materials dropoff area. Current illegal parking activity on this street results in frequent blockage of the curb lane, minimizing the impact of such activity on through traffic flow.

6. Construction worker parking will not be permitted on-site or adjacent to the construction area. All construction workers will be required to access the site by public transportation, ridesharing or by parking at an off-site location.

7. Scheduling of worker shifts so as to minimize conflict with the typical commuting periods.

ROADWAY IMPROVEMENTS

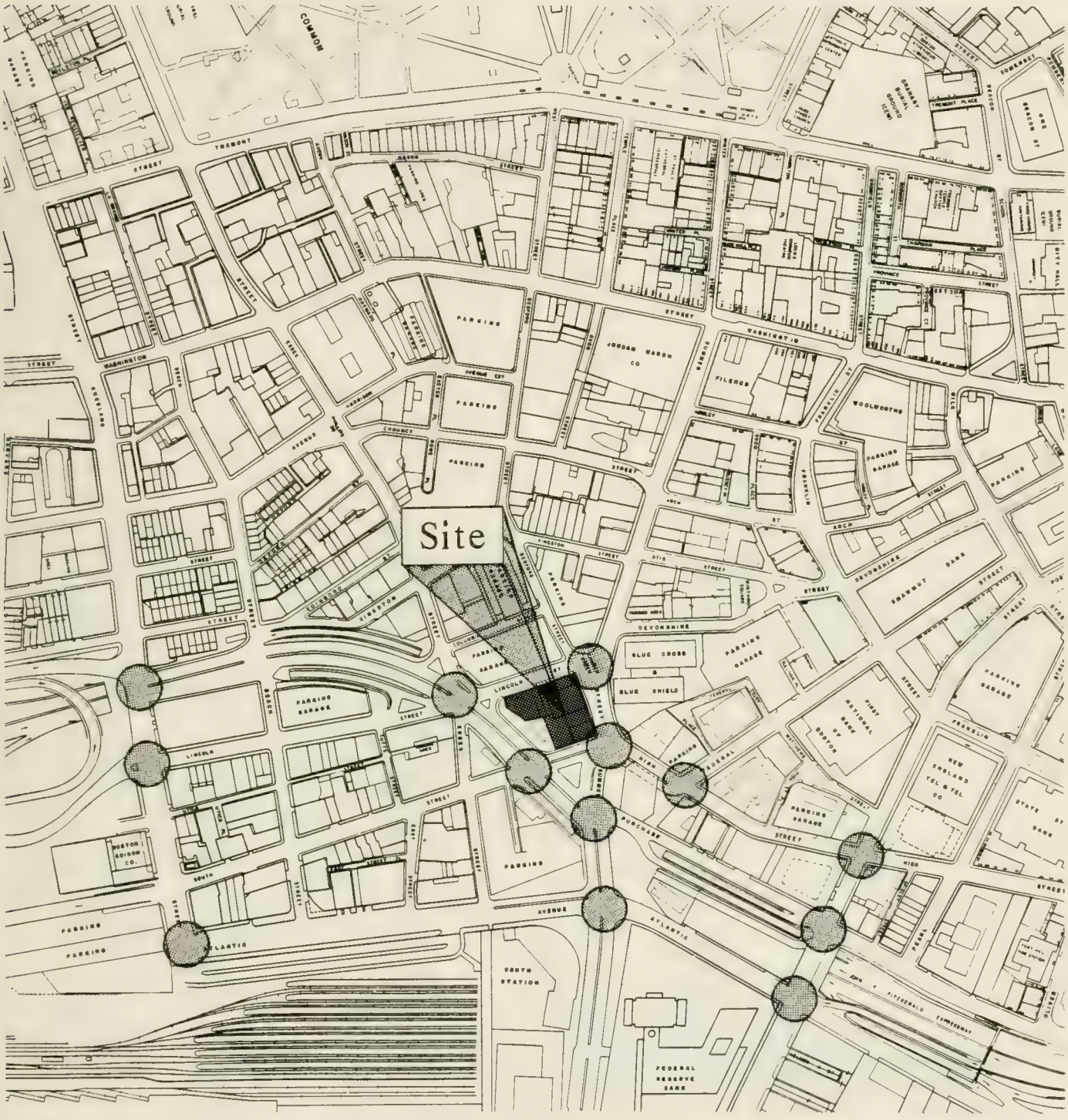
The project's size characteristics, excellent location with respect to public transportation services, and the proponent's proposed commitment to various demand/reduction strategies all will result in relatively small traffic impacts at the key locations analyzed. Nevertheless, the proponent recognizes the desirability of improving traffic circulation within the Dewey Square area so as to maximize efficiency of traffic flow to/from the project site. Therefore, the proponent has committed to work with the City and to support implementation of its proposed Transportation Systems Management improvement program for Dewey Square.

As a result of this study, certain intersection improvements have been identified which will improve volume-to-capacity ratios and reduce congestion. Improvements are delineated below for the three intersections which will be impacted by the project and will operate at LOS "F".

- Congress Street/Atlantic Avenue - The evening peak hour level of service can be improved from "F" to "E" by making the northbound curb lane available for traffic. This would entail enforcement of an existing restriction on parking during the evening peak period. Use of this lane as a travel lane would reduce the V/C ratio from 1.04 to 0.95.

- Kneeland Street/Surface Artery/Expressway Ramp - Short of major reconstruction, mitigation measures for this intersection cannot be feasibly implemented. Presently, all existing approach lanes are fully utilized by peak hour traffic. Also, due to the fact that this intersection is part of a system of coordinated traffic signals, changes in cycle length or phasing could result in adverse impacts on the operation of other downtown intersections.

- Summer Street/Atlantic Avenue - Changes at this intersection involve providing the curb lane on northbound and westbound approaches for travel. This would result in an increase in the morning level of service from "F" to "C" and a decline in V/C ratio from 1.09 to 0.78. In the evening, level of service would improve from "F" to "E" and the V/C ratio would decline from 1.12 to 0.91. The difficulty in enforcing a restriction at the front of South Station is clearly an important issue that must be addressed before implementing such a change. However, elimination of parking only from Atlantic Avenue will also contribute to improved V/C ratios.



Site Location and Study Intersections

LEGEND:

Intersection Study Location

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=400'

Fig. 4.4.1

Study Area Circulation

LEGEND:

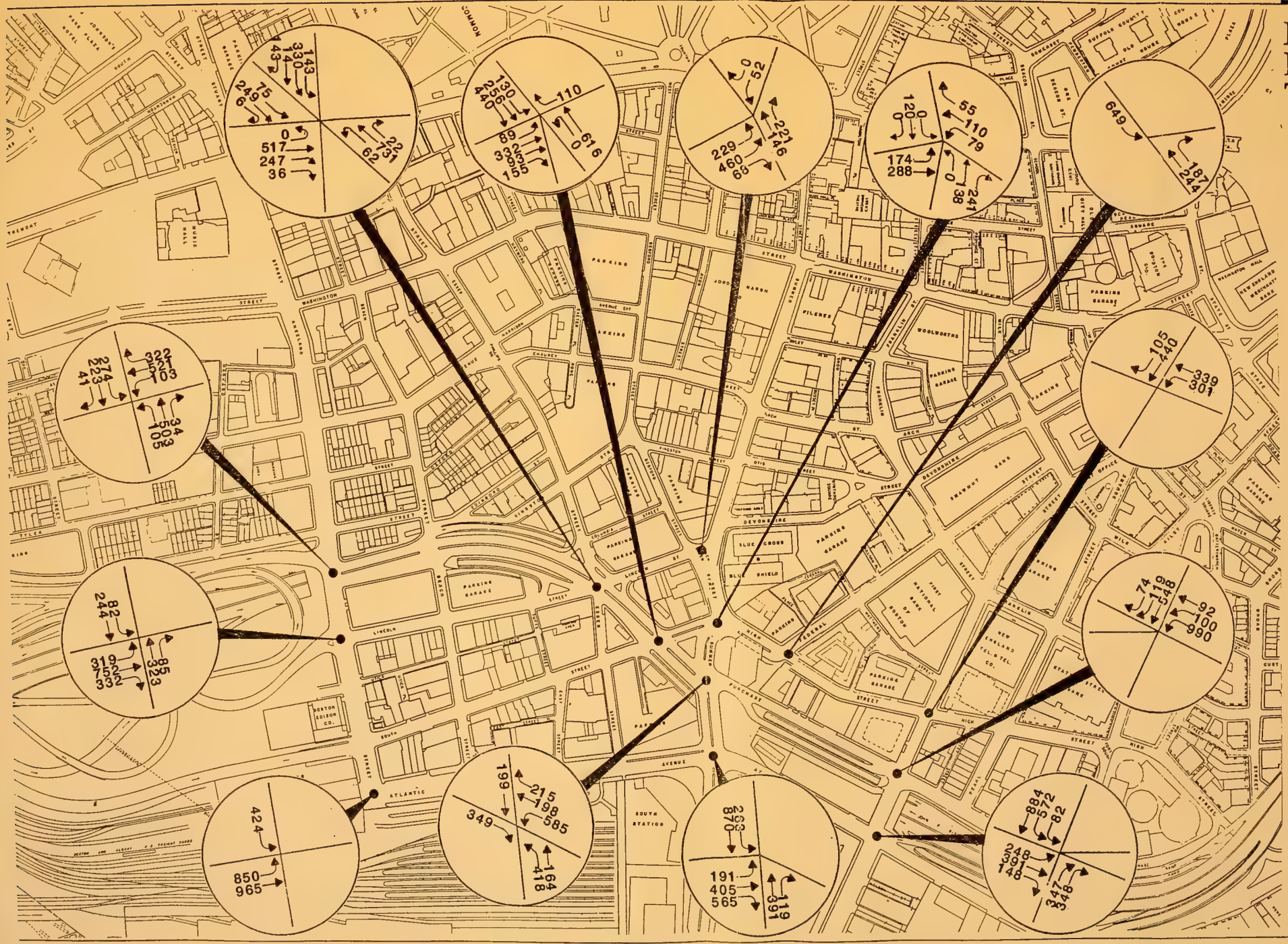
Site

Direction Of Travel

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=400'

Fig. 4.4.2

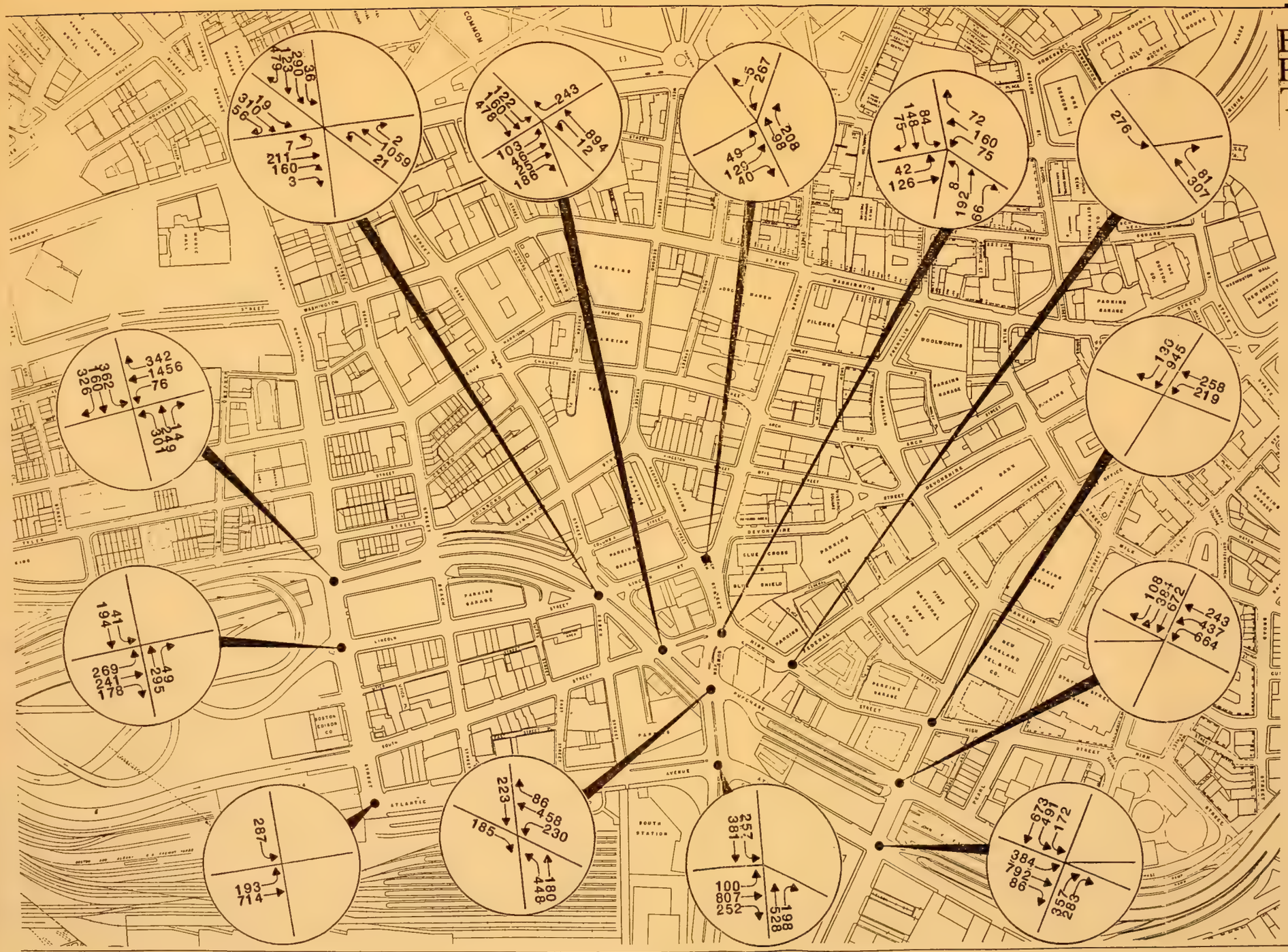


Existing A.M. Peak Hour Traffic Volumes

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=325'

Fig. 4.4.3

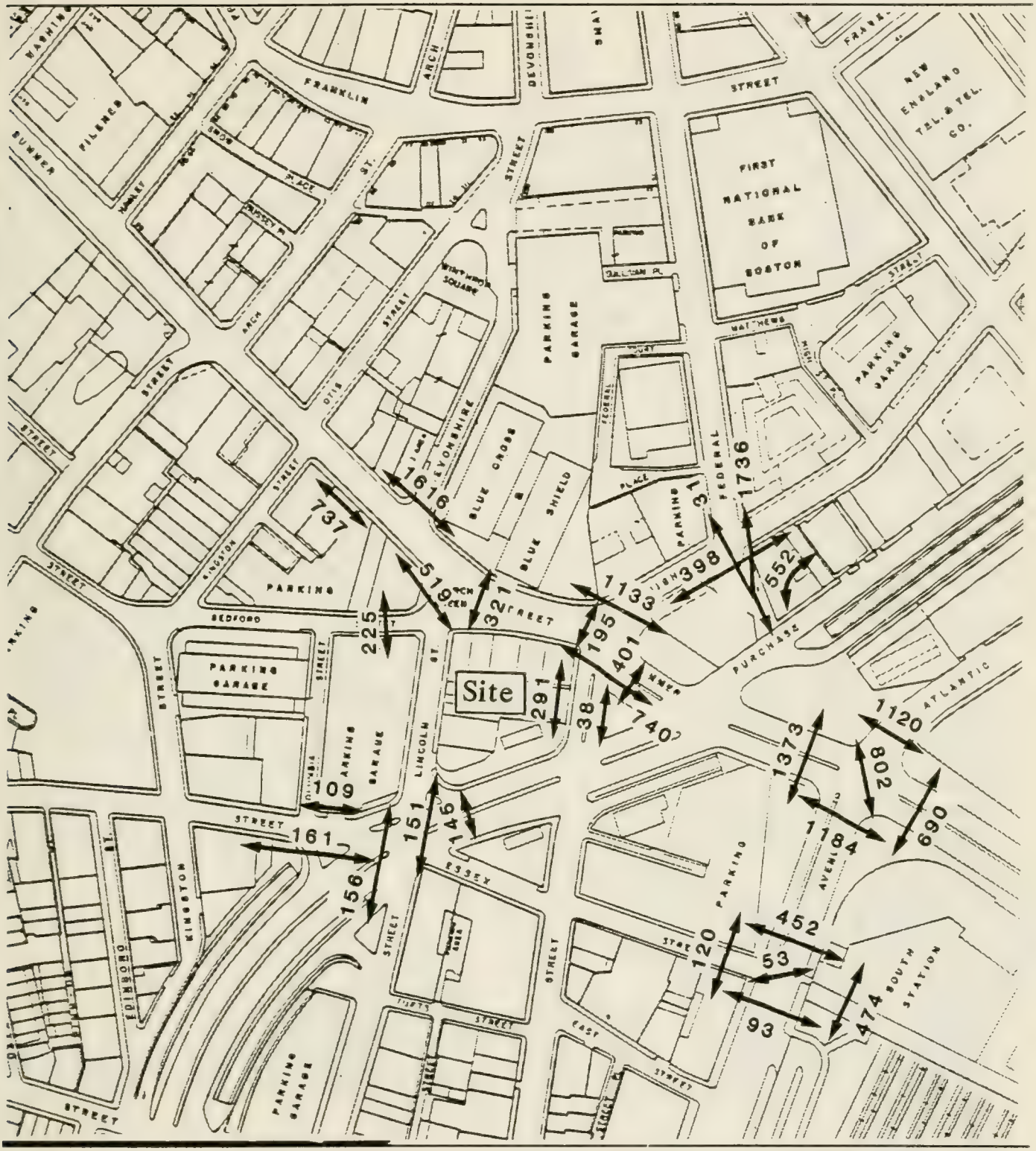


Existing P.M. Peak Hour Traffic Volumes

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=325'

Fig. 4.4.4



Existing
A.M. Peak Hour
Pedestrian Flows
7:30–8:30

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Scale: 1" = 200'

Fig. 4.4.5

LEGEND:

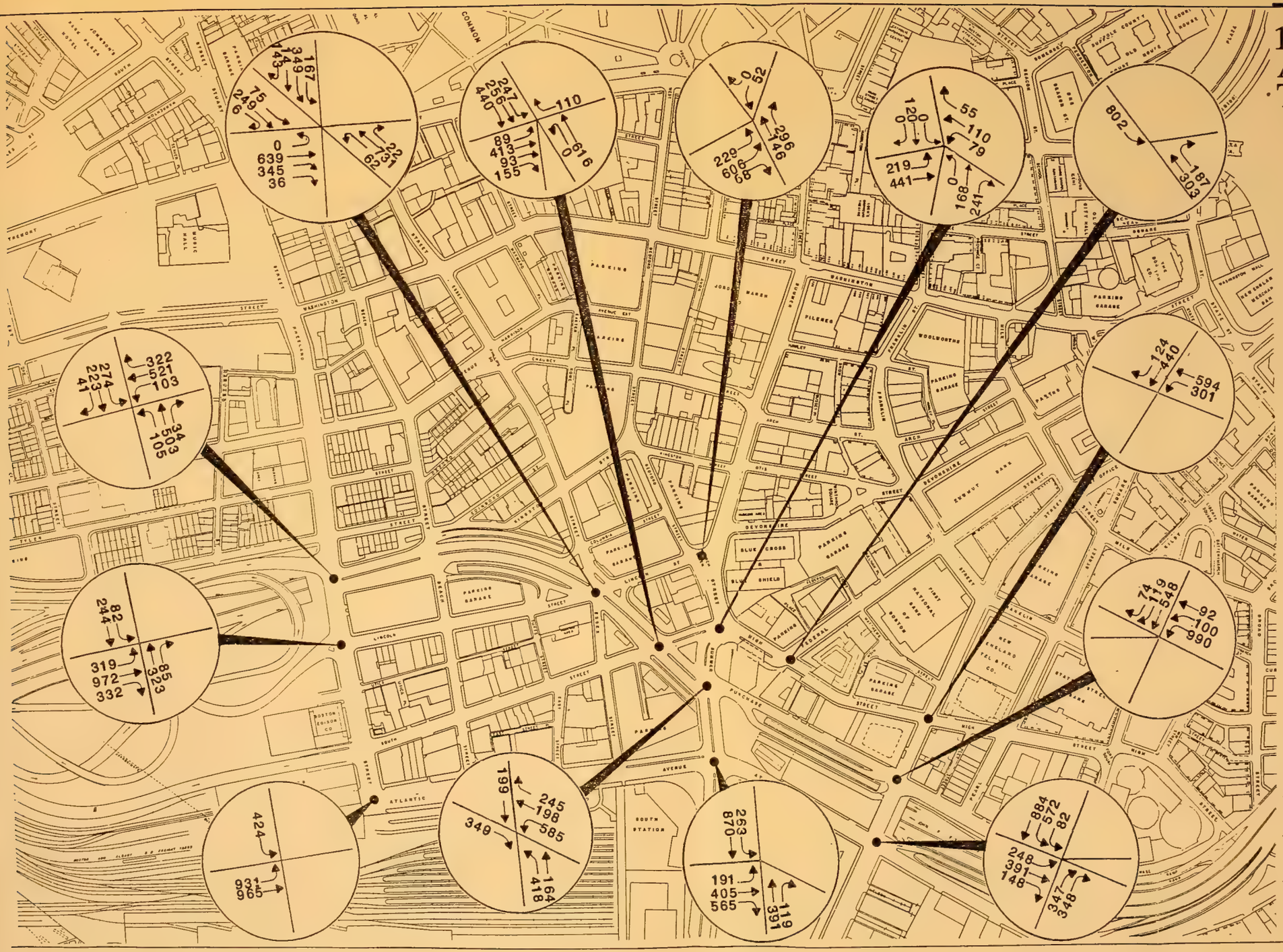
Site

Vanasse/Hangen
Consulting Engineers & Planners
60 Burmingham Parkway, Boston, MA 02135

SCALE: 1"=400'

Trip Distribution Map

Fig. 4.4.8

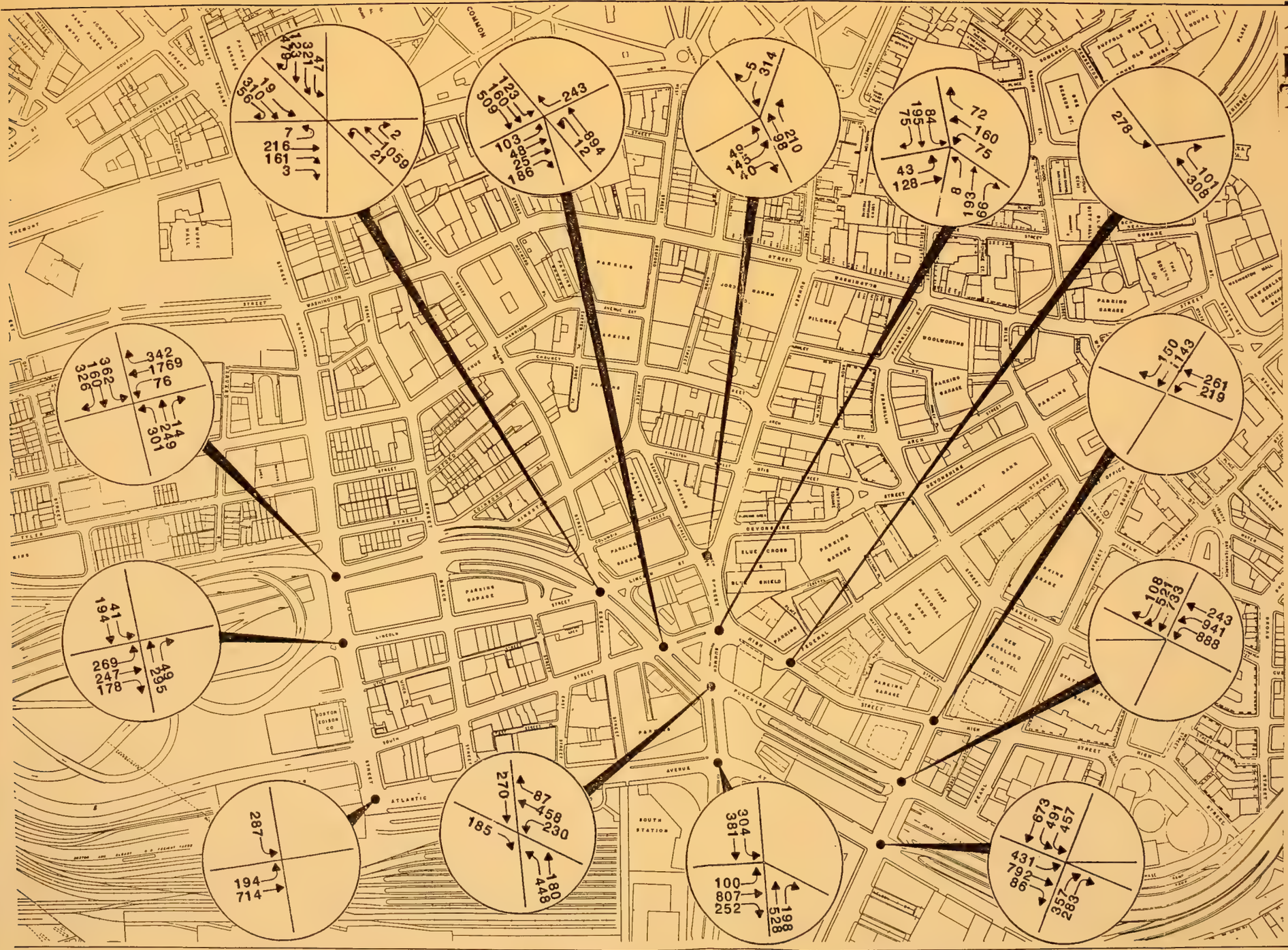


1989 No Build A.M. Peak Hour Traffic Volumes

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=325'

Fig. 4.4.9

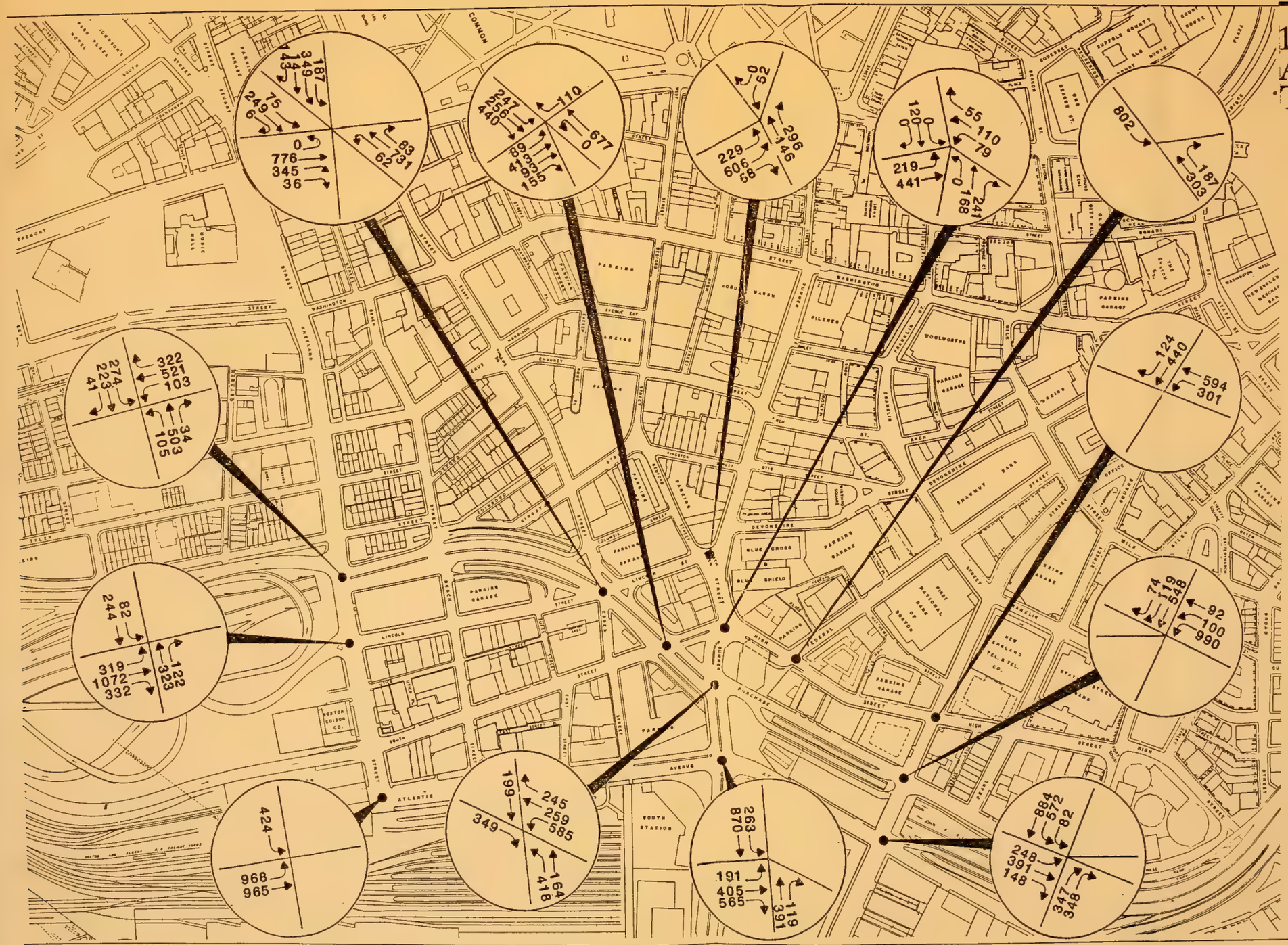


1989 No Build P.M. Peak Hour Traffic Volumes

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=325'

Fig. 4.4.10



1989 Build A.M. Peak Hour Traffic Volumes

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=325'

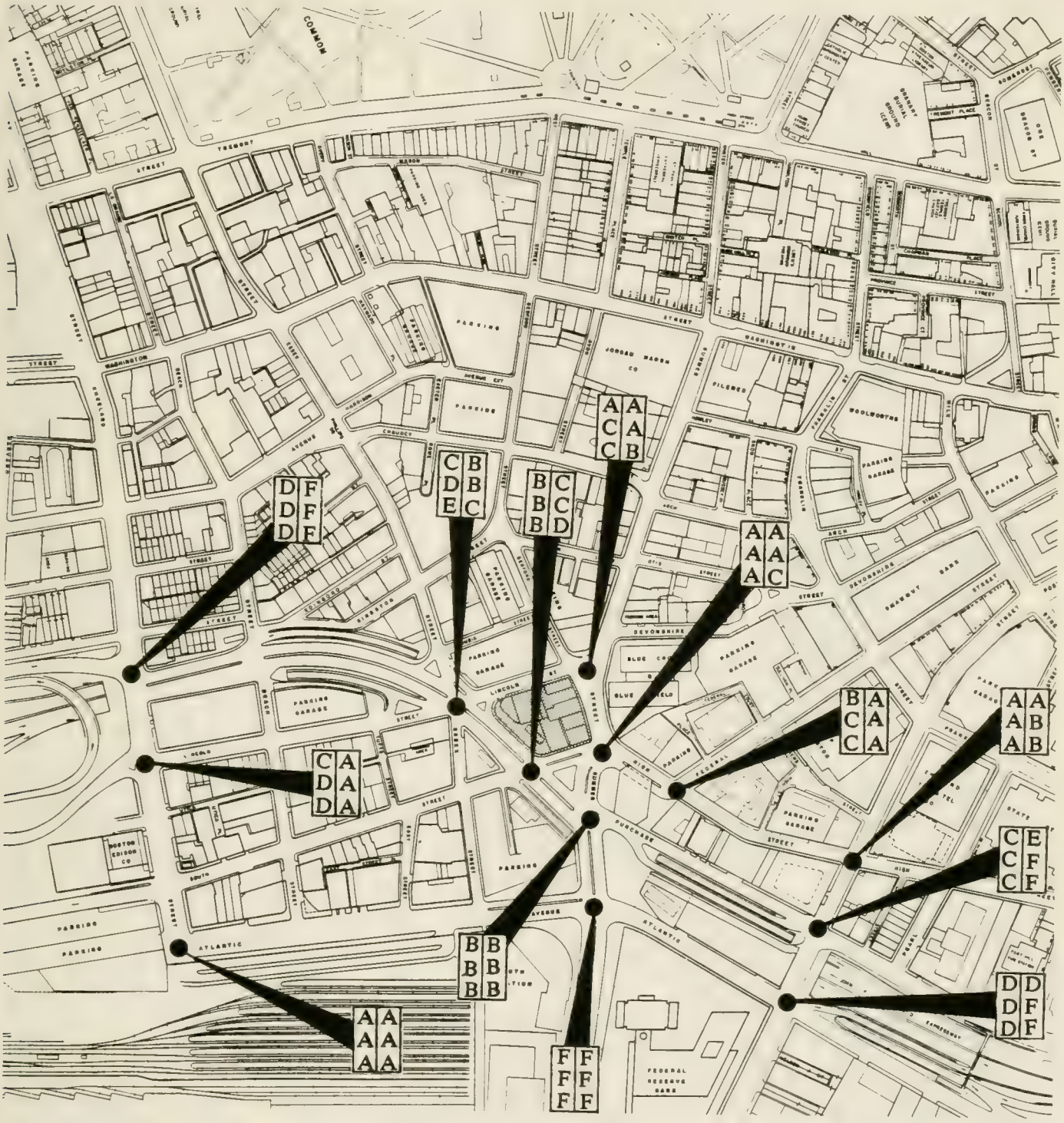
Fig. 4.4.11

1989 Build P.M. Peak Hour Traffic Volumes

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

SCALE: 1"=325'

Fig. 4.4.12



Intersection Level of Service

LEGEND:

AM/PM

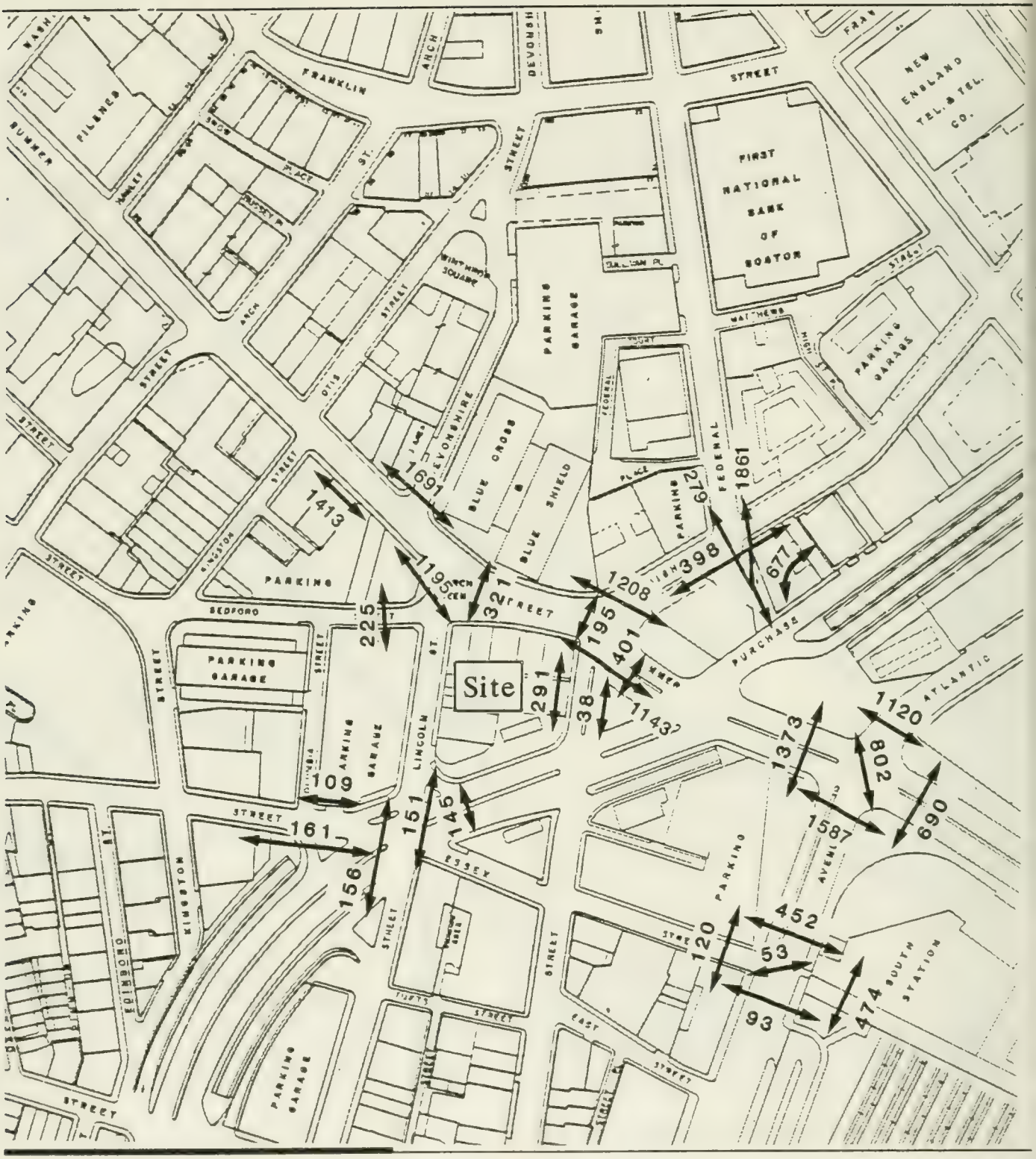
X X Existing
X X No-Build
X X Build

SITE

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Scale: 1" =400'

Fig. 4.4.13

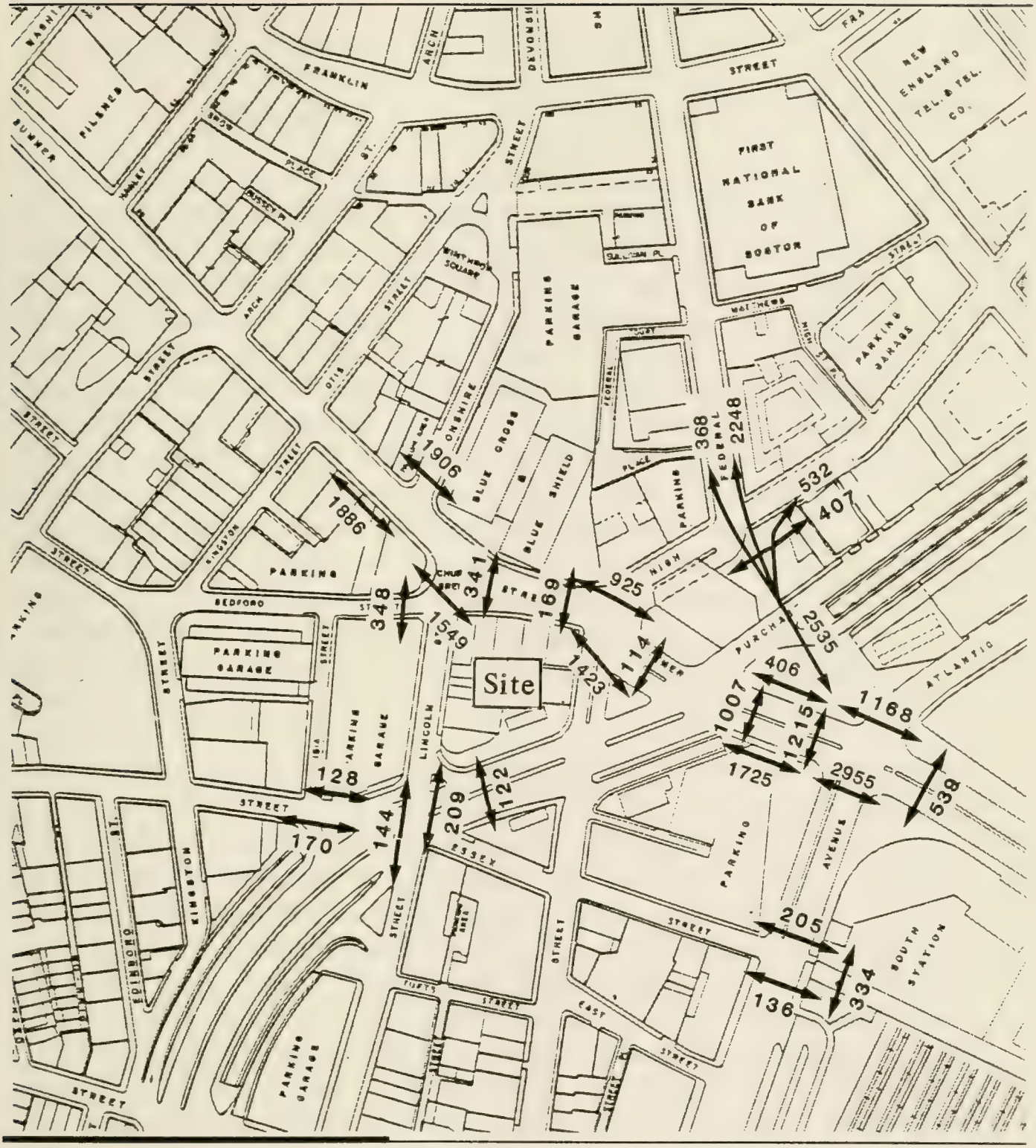


1989
A.M. Peak Hour
Pedestrian Flows
7:30–8:30

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Scale: 1" =200'

Fig. 4.4.14



1989
P.M. Peak Hour
Pedestrian Flows
4:30–5:30

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Scale: 1" = 200'

Fig. 4.4.15

4.5 Air Quality Impacts

4.5.1 Objective

The objective of this analysis is to determine project-related impacts of carbon monoxide associated with construction of 125 Summer Street. Both existing and future levels were examined for comparison to the Massachusetts and National Ambient Air Quality Standard (NAAQS) for carbon monoxide. The standards, established by the Federal Clean Air Act, are designed to protect both public health and welfare. To demonstrate compliance, it is necessary to identify those areas of human activity (sensitive receptors) exposed to maximum air pollutant levels from motor vehicle emissions in the project area. Using air quality modeling techniques, carbon monoxide levels are estimated at these sensitive receptors for the present and future years. Comparison of projected pollutant levels to the NAAQS permits evaluation of whether motor vehicle emissions will pose a threat to public health or welfare.

4.5.2 Pollutant Sources and Effects

Of the six pollutants regulated by the NAAQS, four are emitted by motor vehicles or formed from their emissions: carbon monoxide (CO), nitrogen oxides (NO_x), ozone (O_3), and lead (Pb). Carbon monoxide is used in this analysis as an indicator of roadway air pollution levels, since it is the most abundant and persistent pollutant emitted by motor vehicles. Further, its nonreactive properties over the short term allow pollutant transport and dispersions to be modeled.

The adverse health effects of carbon monoxide are a result of its combination with blood hemoglobin to form carboxyhemoglobin (COHb). As CO replaces oxygen in the red blood cells this compound reduces the amount of oxygen

available to the lungs and body tissues. The presence of relatively small amounts of CO results in significant interference with essential cardiovascular-respiratory functions. Relatively brief exposure to high levels over 40 part per million (ppm) can impair perception, discrimination, and other psychomotor functions.

National Ambient Air Quality Standards (NAAQS) for carbon monoxide have been set by the U. S. Environmental Protection Agency (EPA). Standards for the Commonwealth of Massachusetts are identical to the Federal standards. The primary standards which exist for CO are intended to protect the public health. The target date for attainment of national primary and secondary standards in Massachusetts is December 31, 1987. The primary CO standards set a maximum concentration of 35 ppm for a one-hour period, and 9 ppm for eight hours, each not to be exceeded more than once per year.

4.5.3 Background Air Quality

Any microscale analysis requires an estimate of "background" air quality levels. Background levels reflect the contribution of all sources in the project area less the specific intersections analyzed. Currently the Massachusetts Department of Environmental Quality Engineering (DEQE), Division of Air Quality Control maintains a CO monitoring station along Essex Street in downtown Boston. Based on data collected at this monitoring location, background levels of 6.0 ppm (1-hour) and 3.6 ppm (8-hour) have been recommended* for the 125 Summer Street air quality analysis.

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* Personal Communication, Mr. Richard Mertens, Boston Redevelopment Authority (BRA), October 24, 1986

4.5.4 Study Approach

The 125 Summer Street air quality modeling protocol was developed in cooperation with the BRA* and is based on EPA and DEQE approved modeling techniques. The analysis calculated maximum one-hour and eight-hour CO concentrations at sensitive receptors located adjacent to five key intersections in the project area for the following three cases:

Case No.	Year	Project Alternative
1	1986	Existing
2	1989	Build
3	1989	No-Build

For each case, the EPA MOBILE3** and FHWA CALINE3*** computer programs were used to calculate motor vehicle emissions and CO concentrations at intersections. Emission calculations, which are detailed in Appendix C, used the MOBILE3 national cold/hot start mix default values for the peak eight-hour period while a higher cold start mix was utilized for the peak one-hour period. In addition, the analysis incorporated the effects of the Commonwealth's statewide inspection and maintenance (I&M) program. These emissions data were used as input to the CALINE3 model, adapted for intersection analysis,**** to predict CO concentrations. CALINE3 modeling and assumptions are presented in Appendix C.

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* Personal Communication, Mr. Richard Mertens, Boston Redevelopment Authority (BRA), September 29 and October 24, 1986

** EPA, User's Guide to MOBILE3: Mobile Source Emissions Model, EPA-460/3-84-002, Ann Arbor, MI, June 1984.

*** FHWA, CALINE3 - A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets, FHWA/CA/TL-79/23, November, 1979.

**** EPA Region I, Region I Mobile Source Modeling Procedures, January 1, 1985.

Additional analysis was performed to determine the ambient air quality impacts of the project's parking garage ventilation system and the Dewey Square Tunnel ventilation buildings, located to the south side of the project. Emission rates of the project's parking garage ventilation system were calculated using the EPA MOBILE3 computer program and EPA Indirect Source Guidelines* worksheet 3. For the Dewey Square tunnel vent buildings, emission rates were determined using MOBILE3 vehicular emissions with ventilation characteristics provided in the Third Harbor Tunnel/Central Artery Project Environmental Impact Statement**. Halitsky's gas diffusion equation was used to calculate CO impacts of the tunnel vents and garage vents at the same receptors studied in the intersection analysis. This methodology is also detailed in Appendix C.

The air quality analysis examined CO levels at the following five intersections within the study area:

- Atlantic Avenue/Summer Street
- Congress Street/Atlantic Avenue
- Essex Street/Lincoln Street/Surface Artery
- Kneeland Avenue/Surface Artery
- South Street/Surface Artery

These intersections were selected in cooperation with the BRA*** and represent locations where the project results in degradation of traffic below levels of service (LOS) C. Peak PM hour traffic data was selected for analysis of each intersection except the Essex/Lincoln/Surface Artery intersection. At this intersection the peak AM hour data was used as all project-related traffic directed to the proposed parking garage is required to access this intersection.

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* EPA, Guidelines for Air Quality Maintenance Planning and Analysis Volume 9, (Revised): Evaluating Indirect Sources, Second Printing, EPA-450/4-78-001, Research Triangle Park.

** FHWA and MDPW, Final EIS: Third Harbor Tunnel Interstate 90/Central Artery, Interstate 93, FHWA-MA-EIS-82-02-F, August 1985 (Appendices)

*** Personal Communication, Mr. Richard Mertens, Boston Redevelopment Authority (BRA), September 29 and October 24, 1986

Pedestrian activity was assumed to decrease roadway capacities during the peak one-hour by 20 percent at the Essex/Lincoln/Surface Artery and Surface Artery/South Street intersections. Reductions of 30, 19 and 10 percent were similarly used for Atlantic/Summer Street, Kneeland/Surface Artery and the Congress/Atlantic Avenue intersections, respectively. For all intersections peak eight-hour traffic volumes were calculated by multiplying peak one-hour levels with a conservative factor of 0.82. This factor, relating peak eight hour traffic volumes to peak one-hour volume, is based on traffic counts taken in the Dewey Square area.

Since carbon monoxide emissions are greatest at roadway intersections due to vehicle idling, acceleration and deceleration, sensitive receptors in close proximity to "worst case" intersections were selected. The receptor locations were chosen to be consistent with the recommendations in EPA Guidelines* namely: 1) where maximum carbon monoxide concentrations are likely to occur (i.e., adjacent to intersection vehicle queues), and 2) where the general public is likely to have access. Figures 4.5-1 through 4.5-5 are drawn approximately to scale and summarize the source - receptor geometry of each intersection analyzed. All intersections studied are controlled by traffic signals.

4.5.5 Results

4.5.5.1 Intersection Analysis

The intersection analysis predicted maximum one-hour and eight-hour CO concentrations at sensitive receptor locations around five intersections using the FHWA CALINE3 computer program. Intersection impacts plus background levels are summarized in Table 4.5-1.

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* EPA, Guidelines for Air Quality Maintenance Planning and Analysis Volume 9, (Revised): Evaluating Indirect Sources, Second Printing, EPA-450/4-78-001, Research Triangle Park.

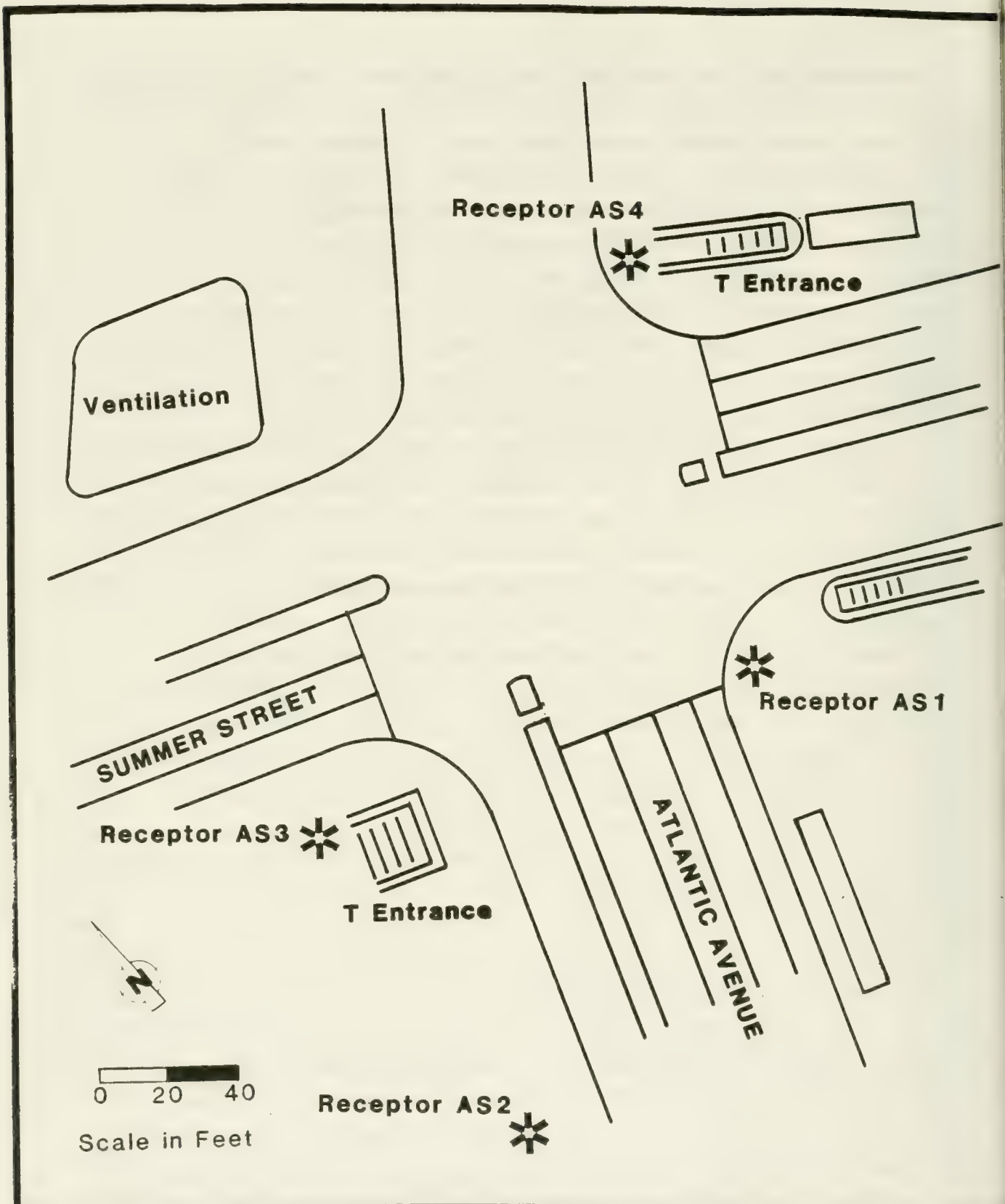

FIGURE 4.5-1 ATLANTIC AVENUE/SUMMER STREET

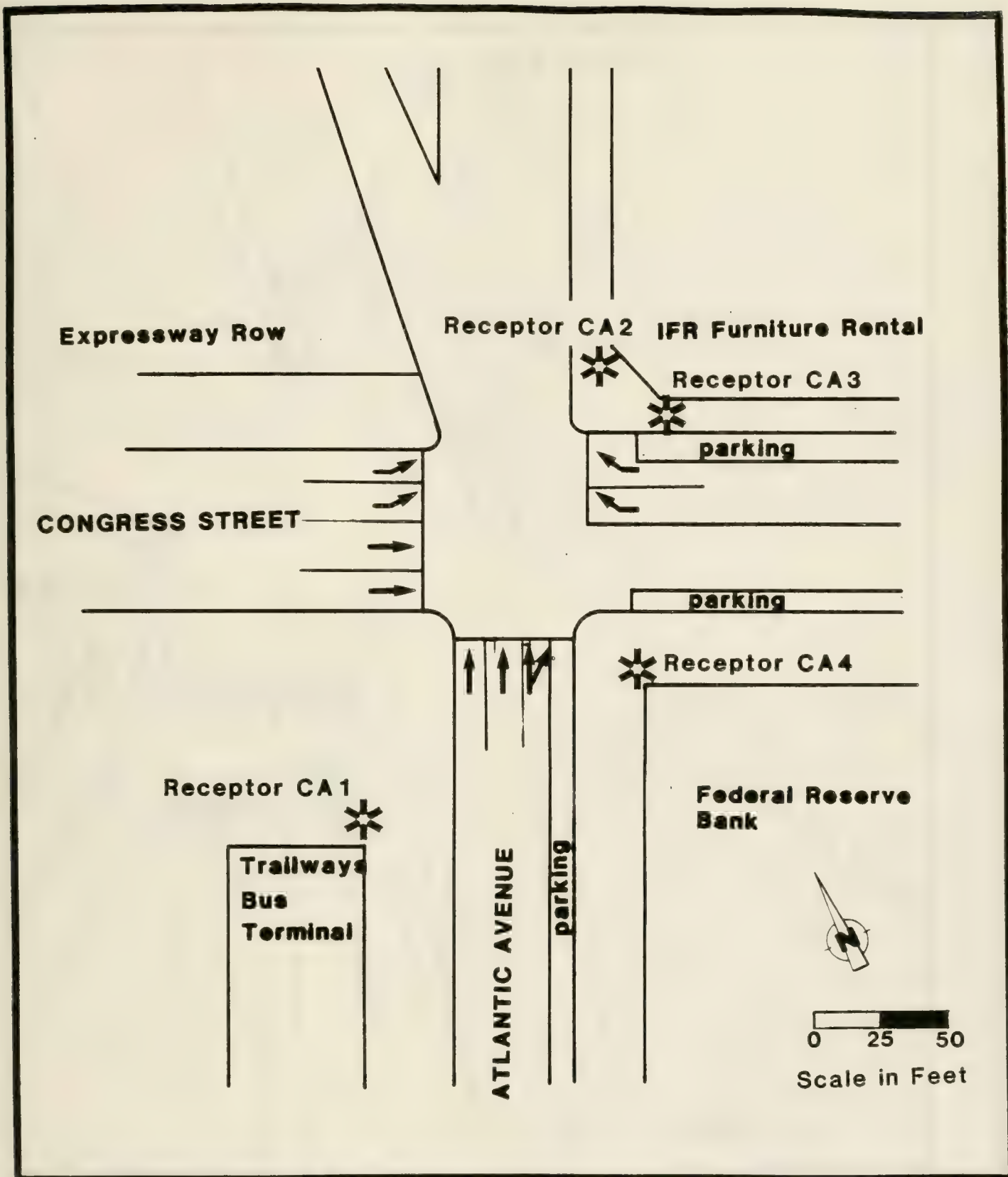

FIGURE 4.5-2 CONGRESS STREET/ATLANTIC AVENUE

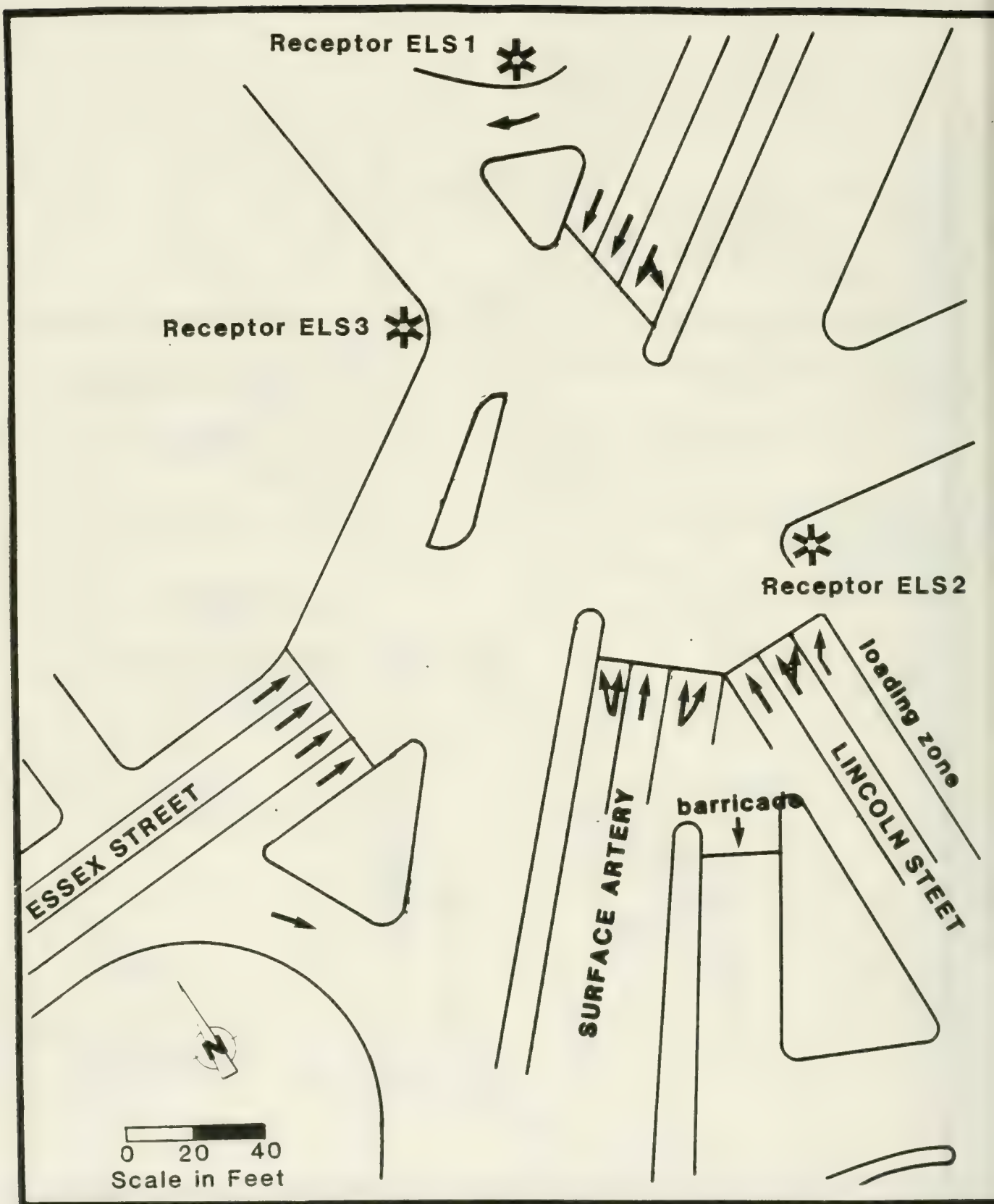

FIGURE 4.5-3 ESSEX STREET/LINCOLN STREET/SURFACE ARTERY

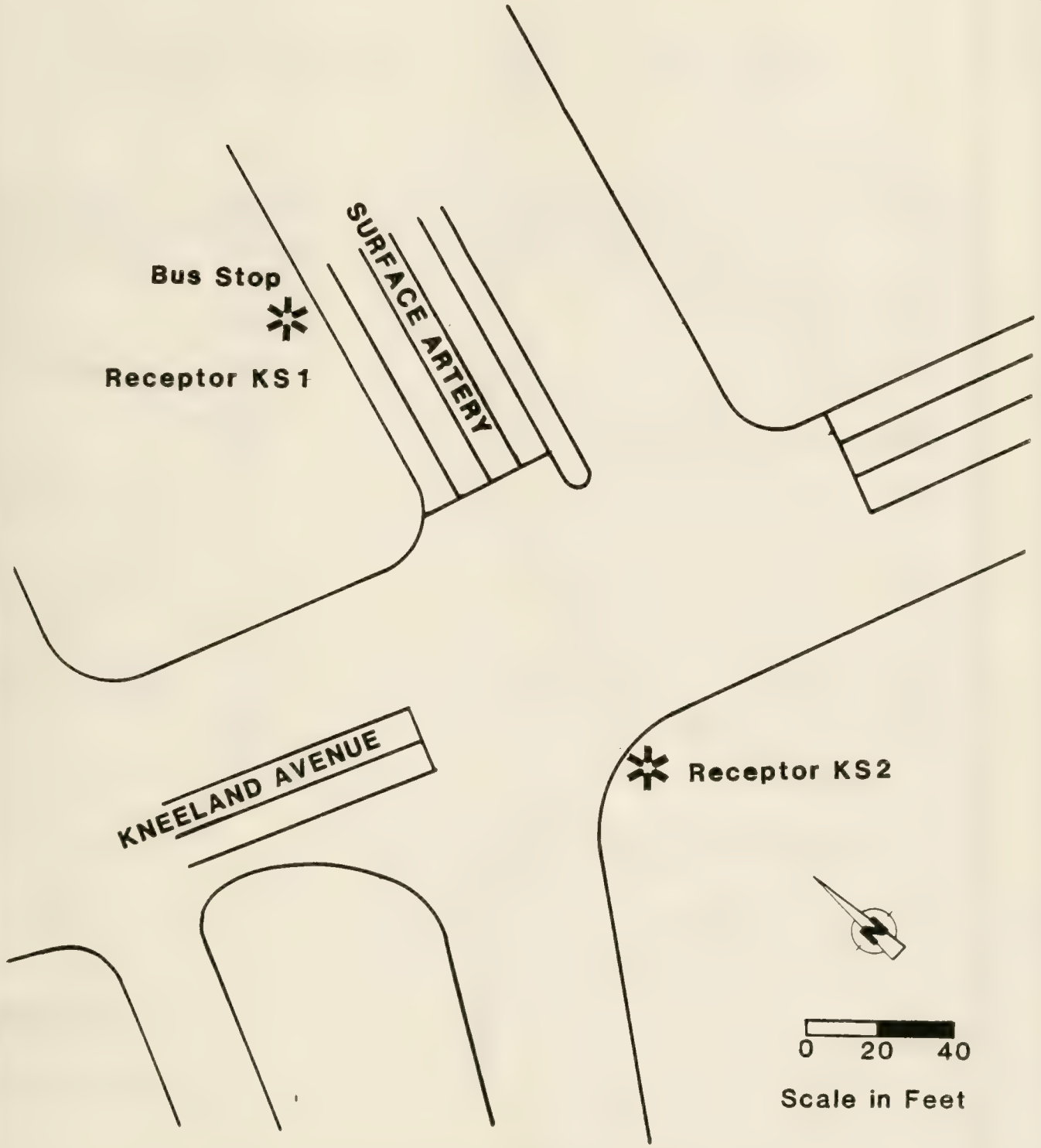

FIGURE 4.5-4 KNEELAND AVENUE/SURFACE ARTERY

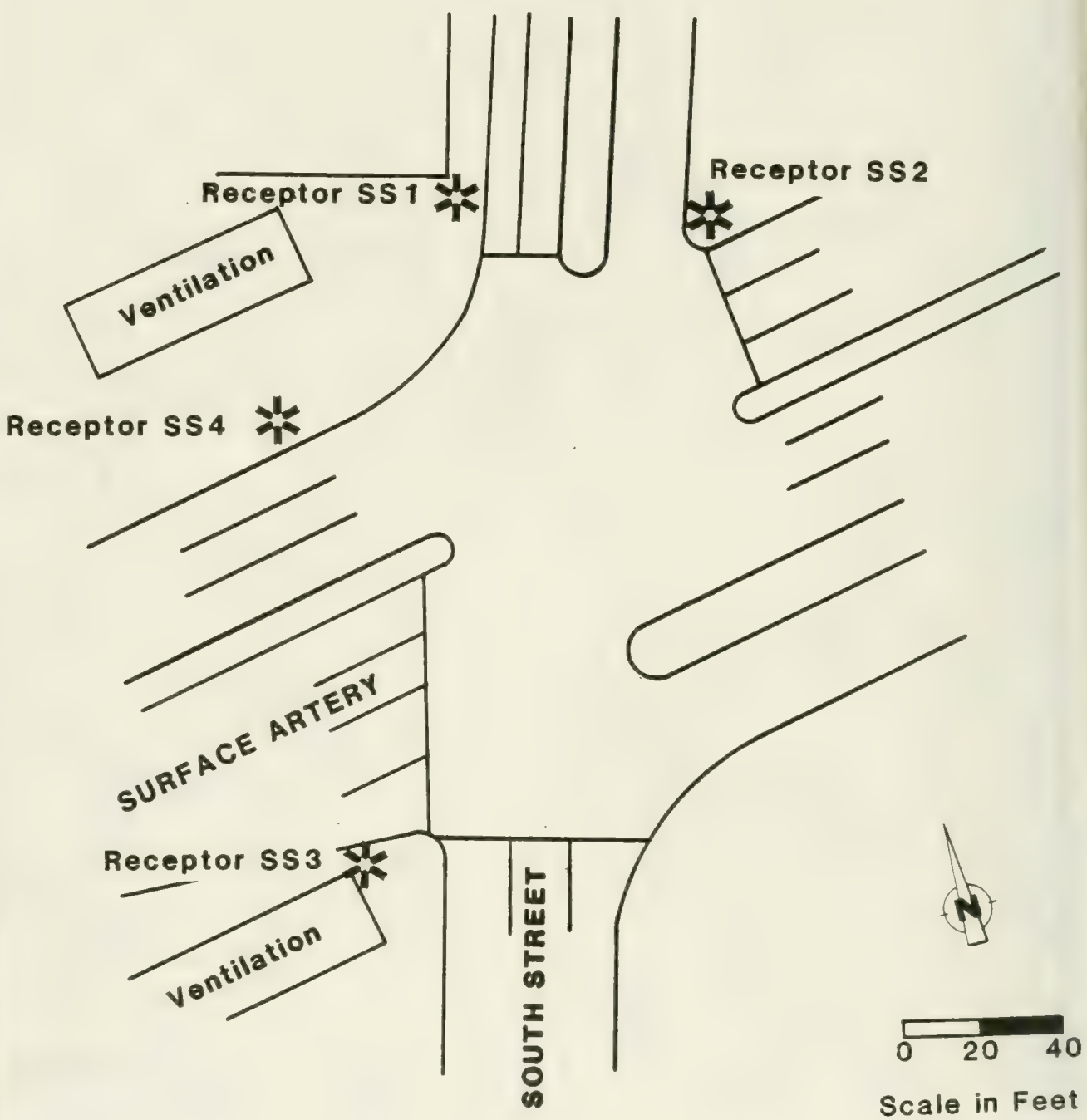

FIGURE 4.5-5 SURFACE ARTERY/SOUTH STREET

TABLE 4.5-1

INTERSECTION ANALYSIS: MAXIMUM PREDICTED CO IMPACTS (PPM)*

Intersection	Receptor	Existing 1 hr	Existing 8 hr	1989 Build 1 hr	1989 Build 8 hr	1989 No-Build 1 hr	1989 No-Build 8 hr
Atlantic/Summer	AS1	34.1	14.1	23.7	10.9	23.7	10.9
	AS2	20.4	10.0	16.3	8.1	16.3	8.1
	AS3	18.7	9.7	15.3	8.1	15.1	7.8
	AS4	28.1	10.8	19.8	8.7	19.7	8.7
Congress/Atlantic	CA1	22.8	11.2	18.1	9.0	18.0	9.0
	CA2	25.1	11.4	20.3	9.3	20.0	9.2
	CA3	26.1	12.2	20.8	9.9	20.6	9.8
	CA4	23.6	11.6	20.2	9.4	20.2	9.3
Essex/Lincoln/ Surface Artery	ELS1	31.4	13.1	27.1	12.6	25.5	10.8
	ELS2	25.4	11.5	23.1	10.2	21.4	9.8
	ELS3	24.5	10.5	20.8	9.0	19.7	8.6
Kneeland/Surface Artery	KS1	42.0	16.4	38.1	15.1	37.0	14.4
	KS2	29.8	11.2	27.3	10.9	26.6	10.4
Surface Artery/ South	SS1	29.3	14.4	23.5	11.3	23.2	11.2
	SS2	24.6	12.5	20.5	9.9	20.4	9.9
	SS3	27.0	13.1	20.9	10.6	20.5	10.5
	SS4	24.3	12.1	19.4	9.6	19.0	9.5

* Background levels included: 6.0 ppm (1-hour) and 3.6 ppm (8-hour).

4.5.5.2 Parking Garage Analysis

A separate analysis was performed to determine carbon monoxide impacts of 125 Summer Street's underground parking garage ventilation system. The parking facility analysis predicted maximum 1-hour and 8-hour CO concentrations at the receptors addressed in the intersection analyses, for the 1989 Build configuration, using Halitsky's gas diffusion equation. Carbon monoxide emissions from the parking garage ventilation system were calculated using the EPA MOBILE3 computer program and Volume 9 Indirect Source Guidelines. Calculations are detailed in Appendix C. Table 4.5-2 summarizes the impacts of the parking garage.

4.5.5.3 Dewey Square Ventilation Building Analysis

Two ventilation buildings for the Dewey Square Tunnel are located in the vicinity of the 125 Summer Street project. One building is located directly adjacent to the project site and vents the southbound lanes of the Dewey Square Tunnel. The second which ventilates the Tunnel's northbound lanes is located across of the Surface Artery near the intersection with Essex Street.

Carbon monoxide impacts associated with these two ventilation buildings were calculated using Halitsky's gas diffusion equation. Contributions at intersection receptors were examined for all existing and future cases. Calculations are detailed in Appendix C and summarized in Table 4.5-3 .

4.5.5.4 Cumulative Results

The cumulative results of the microscale analysis, which include contributions from motor vehicles at each intersection, parking garage ventilation system impacts, Dewey Square Tunnel ventilation building impacts and background levels at each

TABLE 4.5-2

PARKING GARAGE ANALYSIS: MAXIMUM PREDICTED CO IMPACTS (PPM)

Intersection	Receptor	1989 Build 1 hr	1989 Build 8 hr
Atlantic/Summer	AS1	.07	.01
	AS2	.07	.01
	AS3	.11	.01
	AS4	.07	.01
Congress/Atlantic	CA1	.03	.003
	CA2	.02	.003
	CA3	.02	.003
	CA4	.03	.003
Essex/Lincoln/ Surface Artery	ELS1	.33	.04
	ELS2	.13	.02
	ELS3	.19	.03
Kneeland/Surface Artery	KS1	.02	.003
	KS2	.02	.002
Surface Artery/South	SS1	.88	.09
	SS2	.66	.07
	SS3	.29	.03
	SS4	.56	.06

TABLE 4.5-3

DEWEY SQUARE TUNNEL VENTILATION BUILDINGS:
MAXIMUM PREDICTED IMPACTS CO (PPM)

Intersection	Receptor	1986		1989	
		1 hr	8 hr	1 hr	8 hr
Atlantic/Summer	AS1	1.47	.60	1.33	.54
	AS2	1.26	.52	1.14	.47
	AS3	1.76	.73	1.60	.66
	AS4	1.41	.58	1.28	.52
Congress/Atlantic	CA1	.96	.39	.86	.35
	CA2	.82	.34	.74	.31
	CA3	.83	.35	.75	.31
	CA4	.89	.37	.80	.33
Essex/Lincoln/ Surface Artery	ELS1	2.72	.83	2.47	1.01
	ELS2	2.46	1.02	2.22	.91
	ELS3	2.46	1.02	2.22	.92
Kneeland/Surface Artery	KS1	.94	.39	.85	.35
	KS2	.79	.32	.71	.29
Surface Artery/ South	SS1	2.78	1.14	2.51	1.04
	SS2	2.60	1.07	2.35	.97
	SS3	2.90	1.21	2.63	1.08
	SS4	2.93	1.21	2.65	1.09

receptor are presented in Table 4.5-4. These results do not characterize typical air pollution levels in the study area. Rather, they represent the highest concentrations that could exist during the joint occurrence of worst case meteorology and peak traffic. In addition, the full CO contribution from the parking garage and Dewey Square ventilation buildings were included regardless to whether or not the wind was directly in line with each receptor.

In general, maximum impacts indicate the project is not the cause of an exceedance of the NAAQS at any receptor location modeled. Maximum project impacts do add to predicted existing 8-hour violations, and, in the case of Kneeland Avenue/Surface Artery intersections, a 1-hour violation as well. Project-related increases, however, are in most cases less than 2 ppm for peak one-hour periods and 1 ppm for peak 8-hour periods. Further the results demonstrate the predicted future violations are principally attributed to existing traffic volumes and flow patterns in the project area.

Carbon monoxide impacts at each intersection are as follows:

Atlantic Avenue/Summer Street:

The air quality analysis, at this intersection, did not predict a violation of the CO one-hour NAAQS of 35 ppm for either the Build or No-Build case. The model produced a result of 35.6 ppm (0.6 ppm above the standard) for the existing configuration at receptor AS1 at the corner of South Station. Likewise, the highest eight-hour level of 14.7 ppm was predicted under the existing configuration at this receptor. This concentration is 5.7 ppm above the eight-hour CO standard of 9.0 ppm.

During future cases overall CO levels are lower than during existing cases, although exceedances of the eight-hour CO standard of 9.0 ppm are still projected at receptors AS1 and AS4. In both cases, however, worst case winds are from the south/southwest direction. Under these wind conditions, the

TABLE 4.5-4

CUMULATIVE MAXIMUM PREDICTED CO IMPACTS (PPM)*

Intersection	Receptor	Existing 1 hr	Existing 8 hr	1989 Build 1 hr	1989 Build 8 hr	1989 No-Build 1 hr	1989 No-Build 8 hr	NAAQS 1 hr	NAAQS 8 hr
Atlantic/Summer	AS1	35.6	14.7	25.1	11.5	25.0	11.4	35.0	9.0
	AS2	21.7	10.5	17.5	8.6	17.4	8.6	35.0	9.0
	AS3	20.5	10.4	17.0	8.8	16.7	8.5	35.0	9.0
	AS4	29.5	11.4	21.2	9.2	21.0	9.2	35.0	9.0
Congress/Atlantic	CA1	23.8	11.6	19.0	9.4	18.9	9.4	35.0	9.0
	CA2	25.9	11.7	21.1	9.6	20.7	9.5	35.0	9.0
	CA3	26.9	12.6	21.6	10.2	21.4	10.1	35.0	9.0
	CA4	24.5	12.0	21.0	9.7	21.0	9.6	35.0	9.0
Essex/Lincoln/ Surface Artery	ELS1	34.1	13.9	29.9	13.7	28.0	11.8	35.0	9.0
	ELS2	27.9	12.5	25.5	11.1	23.6	10.7	35.0	9.0
	ELS3	27.0	11.5	23.2	10.0	21.9	9.5	35.0	9.0
Kneeland/Surface Artery	KS1	42.9	16.8	39.0	15.5	37.9	14.8	35.0	9.0
	KS2	30.6	11.5	28.0	11.2	27.3	10.7	35.0	9.0
Surface Artery/ South	SS1	32.1	15.5	26.9	12.4	25.7	12.2	35.0	9.0
	SS2	27.2	13.6	23.5	10.9	22.8	10.9	35.0	9.0
	SS3	29.9	14.3	23.8	11.7	23.1	11.6	35.0	9.0
	SS4	27.2	13.3	22.6	10.8	21.7	10.6	35.0	9.0

* Background levels included: 6.0 ppm (1-hour) and 3.6 ppm (8-hour).

ventilation buildings and project garage located to the northwest of this intersection would not have an impact at either receptor AS1 or AS4. Therefore, actual predicted eight-hour levels for both the build and no-build conditions would be those shown in Table 4.5-1 (intersection plus background), 10.9 ppm and 8.7 ppm, respectively. Thus there would be no violation at receptor AS4.

Congress Street/Atlantic Avenue:

Under the existing case no violations of the one-hour NAAQS were predicted at this intersection. However for this case, the maximum predicted eight-hour results ranged from 11.6 ppm to 12.6 ppm. These results represent exceedances of the 8-hour NAAQS of 9 ppm. The air quality analysis for 1989 shows a general decrease from CO levels from 1986, but does predict violations of the eight-hour NAAQS of 9 ppm at all receptors in both build and no-build scenarios.

At each of the receptors except CA1 an eight hour project impact of 0.1 ppm is predicted. CO levels in the build case exceed the 9.0 ppm standard by 0.6 ppm at CA2, 1.2 ppm at CA3, and 0.7 at CA4. At receptor CA1, located at the corner of the bus terminal, the project does not contribute to the predicted maximum concentration of 9.4 ppm (0.4 ppm above the acceptance standard).

Essex Street/Lincoln Street/Surface Artery:

In the existing case no violations were predicted for the peak one-hour periods. However, exceedences of the eight-hour NAAQS of 9.0 ppm are expected at all three receptors. In future cases both build and no-build modeling predict lower CO levels from 1986, with violations of the eight-hour CO standard still occurring at all receptors.

Overall, the largest increases due to the project are predicted at this intersection. At receptor ELS1 located at the southwest corner of the project the analyses shows a 1.9 ppm eight-hour increase with construction of the project. The principle cause of this increase is traffic travelling to the proposed parking garage entrance on Lincoln Street in the peak AM hour. At this intersection two opposing queues equally contribute to the CO level: the northbound Lincoln Street queue and the southbound Surface Artery queue.

Kneeland Avenue/Surface Artery:

In all cases the air quality analysis predicted violations of the 1-hour NAAQS of 35 ppm at receptor KS1, located at a bus stop at the north corner of the intersection. Violations of the 8-hour NAAQS of 9.0 ppm were predicted at both receptors under all cases. Under existing conditions the analyses indicated a maximum peak one-hour result of 42.9 ppm at receptor KS1, a 7.9 ppm exceedance of the one-hour standard. Likewise, the highest eight-hour concentration was predicted at receptor KS1. Here a concentration of 16.8 ppm was calculated under the existing case; this is 7.8 ppm above the standard.

In future cases predicted levels of CO decrease but are still in violation of air quality standards. Small inceases due to the project are also expected. For the one-hour period the project resulted in an increase from 37.9 ppm to 39.0 ppm at receptor KS1 and 27.3 ppm to 28.0 ppm at KS2. For the eight-hour period increases of 0.7 ppm and 0.5 ppm are predicted at receptors KS1 and KS2 respectively.

South Street/Surface Artery:

In all cases there are no predicted violations of the one-hour NAAQS for CO of 35 ppm. There are, however, predicted violations of the eight-hour NAAQS of 9.0 ppm at all receptors for existing and future cases. The model shows a decrease of CO levels for both build and no-build scenarios from the existing case.

There are small increases in the eight-hour CO levels due to the project. The greatest is 0.3 ppm at receptor SS1 located at the southeast corner of the project. At this receptor location the highest future eight-hour CO level (for this intersection) of 12.5 ppm was predicted. This level is 3.5 ppm greater than the 8-hour standard of the 9.0 ppm .

4.5.6 Mitigation Measures

Inspection Maintenance Program

The Commonwealth's I&M program started on April 1, 1983 and has been assumed in the calcuation of motor vehicle emission rates. This program, which results in the overall reduction of yearly motor vehicle emissions, was established to ensure compliance with the NAAQS as outlined in the Massachusetts State Implementation Plan. The attainment and maintenance of the NAAQS for CO in the future is dependent on the continued enforcement of this program.

Traffic Demand Reduction Measures

Other traffic related mitigation measures to reduce vehicle conflicts and delays should similarly improve existing and future air quality. Such measures to which the projects proponents are directly committed include:

- Promotion and sponsorship of various carpool/vanpool organizations within the building and area;

- Provision of an onsite location for sale of MBTA passes and private bus line tickets. Provision of bus, commuter rail, commuter boat schedules and promotional and informational material for all forms of public transportation;

- o Subsidization of MBTA passes on weekly/monthly commuter tickets for proponent's employees and encouraging tenants to do the same;

- o Implementing staggered work hours, flexible work hours or compressed work weeks for proponents employees, and encouraging tenants to do the same during the lease negotiation process;

- o Restricting delivery vehicles to off-peak hours.

Complete plans for traffic demand reduction are detailed in Section 4.4.4 of the Transportation Impacts Access Plan.

Capacity Enhancement of Roadways

Other traffic related changes which would produce positive effects in reducing vehicle emissions are signal changes which enhance traffic movement, roadway geometry changes which increase roadway capacities, and removal of on-street parking which also increases roadway capacities.

The least complicated method for increasing capacity and decreasing carbon monoxide levels at receptor locations is changing the signal timings to more appropriately match the traffic demand at the intersections.

By changing the signal timings at the Kneeland Avenue/Surface Artery intersection, one hour violations can be eliminated. Proposed timing changes are as follows:

	Total Green Time (sec)	
	Present	Proposed
Kneeland Eastbound (right turns)	74	69
Kneeland Eastbound (unopposed left)	10	10
Kneeland Eastbound (opposed left)	36	20
Kneeland Westbound	36	20
Surface Artery Southbound	42	58

These signal changes result in a decrease of the predicted high CO level at receptor KS1 from 39.0 ppm to 30.8 ppm, and a decrease at receptor KS2 from 28.0 ppm to 23.4 ppm.

Similar changes in signal timing are proposed for the 8 hour case, lowering predicted levels from 15.5 ppm at KS1 to 11.6 ppm, and 11.2 ppm at KS2 to 9.5 ppm. In both cases eight-hour CO levels are still above the acceptable standard.

Signal timing changes were also modelled at the other four intersections studied. At these intersections, however, signal timings were already adjusted for the optimum flow, or opposing traffic flow equally contributed to the level of CO and by decreasing one queue length, another one would increase equally or greater. For example, by adjusting the signal timings at the Atlantic Avenue/ Summer Street intersection so that the green time is proportional to volume/capacity ratio at each link, the predicted level at receptor AS1 is decreased from 10.9 ppm to 10.0 ppm. However, the peak CO level at receptor AS4 increases from 8.7 ppm to 9.4 ppm, and results in another violation of NAAQS. On the basis of Boston's history of wind directions in the last five years, the change is not recommended as low speed winds are more frequent from the southeast (the direction at which the mitigation case causes a peak at receptor AS4) than from the southwest (the direction that the non-mitigation case causes a peak at receptor AS1).

There are a number of traffic flow improvement projects presently being implemented or are in the planning stages that could potentially have major benefits to air quality in the project site area. These improvements include:

- The City of Boston Signal Timing Optimization Plan

- Dewey Square Comprehensive Transportation Systems Management (TSM) Program

- The Third Harbor Tunnel and depressed Central Artery
- A proposed people mover between South Station and the World Trade Center.

These programs are described in more detail in the following sections.

City of Boston Signal Timing Optimization Plan

Currently, the City is in the process of optimizing, through computer operated traffic flow monitors, approximately 250 signals in downtown Boston. Completion of this program is expected by the time 125 Summer Street is fully completed. Computer driven signal timings based on demand should significantly improve traffic flow especially over the peak eight-hour periods when most violations of the CO NAAQS occur. As traffic volumes at intersection approaches change over time, the signal timings will adjust appropriately. Thus, over an eight-hour period signal timings will constantly adjust to maximize traffic flow through downtown Boston. Improvement of traffic flow will reduce conflicts and delays. Air quality analyses utilizing one set of signal timings does not show much improvement, if any, for the eight-hour traffic flow, however signal timings that change as traffic demand changes at an intersection should actually improve eight-hour levels in the project area.

Effect of Dewey Square TSM

The proponent of 125 Summer Street has committed to work with the City and support implementation of its proposed Transportation Systems Management (TSM) improvement program for Dewey Square.

Alternative A for the Dewey Square Program includes making the Surface Artery one-way southbound and making Essex Street two-way between Atlantic Avenue and Kingston Street. Improved capacity and traffic movement on the Surface Artery would potentially decrease CO levels at the intersections of Kneeland/ Surface Artery, Summer/Surface Artery and Lincoln/Essex/Surface Artery. It was at receptors adjacent to these intersections that highest CO levels were generally predicted (see Table 4.5-4).

Alternative B proposes further changes in addition to those proposed in Alternative A. These include making High Street one-way northbound between Summer Street and Atlantic Avenue; making Summer Street one-way eastbound between Lincoln and High Street; eliminating the short eastbound segment of Summer Street between High Street and Purchase Street; and closing South Street between Summer Street and the Surface Artery. Alternative B would therefore eliminate the project's impact during the peak PM hour at the Atlantic Avenue/Summer Street intersection. These traffic impacts however would only be diverted to other intersections.

Changes in the Atlantic Avenue/Summer Street intersection involved eliminating on-street parking along the northbound and westbound approaches for travel. This would result in an increased capacity thus reducing conflicts. Making the northbound curb lane of Atlantic Avenue available for traffic, a primary route for outgoing northbound vehicles from the project site, this additional lane would provide increased traffic capacity at the Congress Street/Atlantic Avenue intersection, thus providing air quality benefits at receptors CA1 through CA4.

Preliminary analyses of both Alternatives A and B of the Dewey Square TSM demonstrated improved air quality at the Atlantic Avenue and Summer Street, Surface Artery and Essex

Street, and Kneeland Street and Surface Artery intersections*. Positive impacts will also be seen at the other two intersections studied in this analysis. Furthermore, any improvement of overall traffic flow in the downtown area should lower background levels of CO which will in effect improve CO levels at every intersection.

Effects of I-90/I-93 Plans

Further roadway improvements in Boston, associated with the Third Harbor Tunnel and depressed Central Artery (as currently being considered) are also expected to improve air quality in the project area. The depressed artery will include the diversion of northbound traffic on the artery around the project area (to the east) instead of through downtown Boston.** As a result, northbound on and off-ramps of the artery to Atlantic Avenue will no longer exist. The diversion of the Artery northbound traffic through the Fort Point Channel area should result in improved traffic flow and air quality at the intersection of Atlantic Atlantic Avenue/Congress Street and Atlantic Avenue/Summer Street.

Another major impact on the study area from the depressed Central Artery is that the Surface Artery would be one-way between Summer Street and Kneeland Street thus providing similar air quality benefits as the Dewey Square TSM at Surface Artery intersections. This project if approved is not expected to be completed for several years following completion of 125 Summer Street.

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* "Air Quality Analysis of the Dewey Square TSM," HMM Document No. 83-438, May 20, 1983.

** Presently funding for this project is not finalized, however, the potential of the project is favorable.

South Station/World Trade Center People Mover

A proposed people mover between South Station and the World Trade Center would have positive impact on the study area by generally removing traffic from downtown streets. This proposal would be expected to result in air quality improvements, however, it is still in the early planning stages.

Emissions Limitations

Another mitigating factor utilized in the air quality analysis is the effects of the federal emissions limits required of automobile manufacturers. The MOBILE3 computer program used to develop emissions for both the intersection and parking garage analyses incorporate these emissions limitations. These emission limits were not, however, factored into background CO levels. For the project area motor vehicle emissions (provided in Appendix C) are reduced by 25 percent from 1986 to 1989. Correspondingly, traffic volumes contributing to background are expected to grow approximately 10 percent during this period. Factoring these elements into the existing one- and eight-hour background levels of 6.0 ppm and 3.6 ppm, translates to 1989 levels of 5.0 ppm and 3.0 ppm, respectively. Utilizing credits of the federal emissions limits "across the board" (carried through background levels as well as CO contribution from the intersection and garage analyses) will result in future one-hour and eight-hour levels being reduced by 1.0 ppm and 0.6 ppm, respectively, in Tables 4.5-1 and 4.5-4.

4.5.7 Proposed Building Effects on Pollutant Dispersion

Following construction of 125 Summer Street the local wind field will be altered thus modifying the transport and diffusion of emissions in the vicinity of the project. Of special concern is the effect on the emissions from the adjacent Dewey Square

Ventilation building. The ventilation building is situated along the south side of the project development site and vents motor vehicle emissions for the Dewey Square Tunnel southbound lanes which are located below ground level.

Wind tunnel and field experiments demonstrate the potential for a stagnation point about two-thirds the way up a high-rise building on the upwind facade.* Below this point winds are deflected to the ground as upper level winds against the upper face of a high-rise building create a downward pressure gradient. Also, turbulence is generated on the sides and roof, and downwind of a cavity of recirculating air on the lee side of the building. The lee side turbulence becomes more evident as an obstacle becomes less rounded and taller. In general, these effects will enhance dispersion as upper level winds are deflected to the ground and pass around the building elements. Induced turbulence will also increase the rate of dispersion on the lee side of a high-rise building. Immediately adjacent to the lee side of the building, in the cavity of recirculating air, pollutants are well mixed such that levels are generally more uniform in this region.

Many of these physical characteristics described above were found in the 125 Summer Street flow visualization study which demonstrated, for most wind directions, that the effect of the project was to enhance mixing of pollutants emitted from the ventilation building. The smoke tracer studies of the proposed project provided the following information by wind direction:

North, Northwest and West Winds

For winds from the northwesterly quadrant the ventilation building is located in the cavity region of recirculating air on the lee side of the 125 Summer Street building. The smoke

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* Hanna, Steven R., Gary A. Briggs, Rayford P. Hosker, Jr., Handbook on Atmospheric Diffusion, Technical Information Center, U.S. Dept. of Energy, 1982, pp. 19.

tracer studies indicated that under the no-build configuration, air flow over the top of the ventilation building will cause pollutants to "swirl" toward ground level in its own wake. Following construction of 125 Summer Street the smoke tracer study demonstrated that pollutants emitted from the ventilation building will be drawn up the lee side of the proposed building and away from street level. Therefore, the project should enhance the mixing of pollutants from the ventilation building.

East, Northeast Winds

For east and northeast wind directions air flow patterns around the ventilation building under the no-build configuration are such that pollutants emitted from the vents are directed to the west along the Surface Artery. Downwash effects of the ventilation building and other nearby buildings were noted. Under the build configuration initial pollutant dispersion appeared similar to that of the no-build configuration. However, as the air stream approached the southwest corner of the project, the air flow was drawn around this corner and vertically up the lee side of the building along Lincoln Street. The project in this case, again, appeared to enhance pollutant dispersion.

Southeast Winds

For southeast winds, the smoke tracer study indicated, under the no-build configuration, the general air flow pattern around the ventilation building to be up and over the existing on-site buildings. Some turbulence due to building wake effects was noted. Construction of the project generally inhibits flow directly to the northwest, causing pollutants emitted from the ventilation building to be forced around the southwest corner of the project. Once around this corner the air flow is drawn

vertically upward on the west side of the proposed building and away from ground level in the lee side cavity region. Thus the project, for southeast winds, is expected to enhance dilution of polluted emissions from the ventilation building.

South Winds

Under the no-build configuration the air flow patterns associated with southerly winds around the ventilation building were similar to those observed for southeast winds. The general pattern was up and over existing project site buildings and toward the north. Under the build configuration, the air stream is drawn toward ground level at the southeast corner of the project site, potentially causing some increase in pollutant levels. One beneficial factor, however, is that observed small wind increases at this corner would have the tendency to dilute pollutant concentrations.

Southwest Winds

Under existing conditions, winds from the southwest cause pollutants emitted from the project site ventilation building to be driven northeast along the Surface Artery. Due to the domineering effects of the 100 Summer Street building, a portion of the air stream is drawn back into the wake of this building. For the build configuration, observations of the smoke tracers indicated, as for southerly winds, the project causes the air flow from over the ventilation building to be drawn toward ground level and around the southeast corner of the project. Once around this corner pollutants are mixed well on the lee side of the project.

Overall, smoke tracer results indicate the project generally enhances mixing of pollutants emitted from the ventilation building by drawing them upward in its wake or cavity region. The only potential trouble spot appears at the

southeast corner of the project site when winds are from the south and southwest. Under these wind conditions, pollutants appear to be drawn down toward ground level at this corner location.

4.5.8 Construction Related Impacts

During the construction period of 125 Summer Street, short-term adverse effects on air quality adjacent to the construction site and along major access routes may occur. Impacts associated with land clearing, ground excavation, cut and fill operations, and construction activities may generate fugitive dust, which results in localized increase in Total Suspended Particulate (TSP) levels.

The major dust emitting activities will occur during the construction activities involving excavation and foundation work. Principal on-site sources of particulate matter include the excavation process and exposed aggregate storage piles. For each source type, emissions will depend on such factors as the properties of emitting surfaces (e.g., soil silt content, moisture content and volume of spoils), meteorological variables and the construction practices employed. It is anticipated that emissions from aggregate storage piles will be minimal as the project site is small thus limiting its storage capacity.

Exposed piles of earth removed in the process of excavation, or aggregate piles of construction material dumped at the site, are potential dust emitters during mechanical disturbance and transfer operations, as well as during high winds. In either case, the bulk of the dust is emitted shortly after the initial loading of a freshly processed aggregate because it is during this period that the fine particles are most easily dislodged. Any subsequent rainfall moistens the interior of the pile and the moisture is released very slowly. Thus, the emissions from storage piles depend primarily on the regional precipitation/evaporation (PE) index. The PE index is

a measure of the precipitation to evaporation ratio and in the contiguous United States ranges from an approximate low of 10 in the arid southwest to approximately 170 in the upper northeast. In the Boston area, the PE index is 132, well above the average for the U.S. as a whole.

The EPA document AP-42* provides an emission factor of 1.2 tons of TSP emitted per acre of construction per month for heavy construction operations. This value is based on field measurements and applies to a typical area having a PE index of 50. Indications are that heavy construction operations are proportional to silt content of the soil, and inversely proportional to the square of the PE Index. A value of 0.17 tons per acre of construction per month was developed for Boston utilizing a PE index of 132 instead of 50.

Applying this factor to the 0.67-acre project site provides an estimated potential for 2.7 tons (about 24 months of construction) of fugitive dust generated from construction activities.

(0.67 acres x 0.17 tons per acre per month x 24 months).

The construction contract will provide for a number of strictly enforced measures to be utilized by contractors to reduce potential fugitive dust emissions and minimize impacts. These include:

- The use of wetting agents on areas of exposed soil on a scheduled basis.
- Use of covered trucks.
- Storage of very few spoils on the construction site.
- Monitoring of actual construction practices to ensure that unnecessary transfers and mechanical disturbances of loose materials are minimized.
- Locating aggregate storage piles away from areas having the greatest pedestrian activity.

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* EPA, Compilation of Air Pollutation Emission Factors, AP-42, RTP, NC, May, 1983, Section 11.2.4.

4.6 NOISE IMPACTS

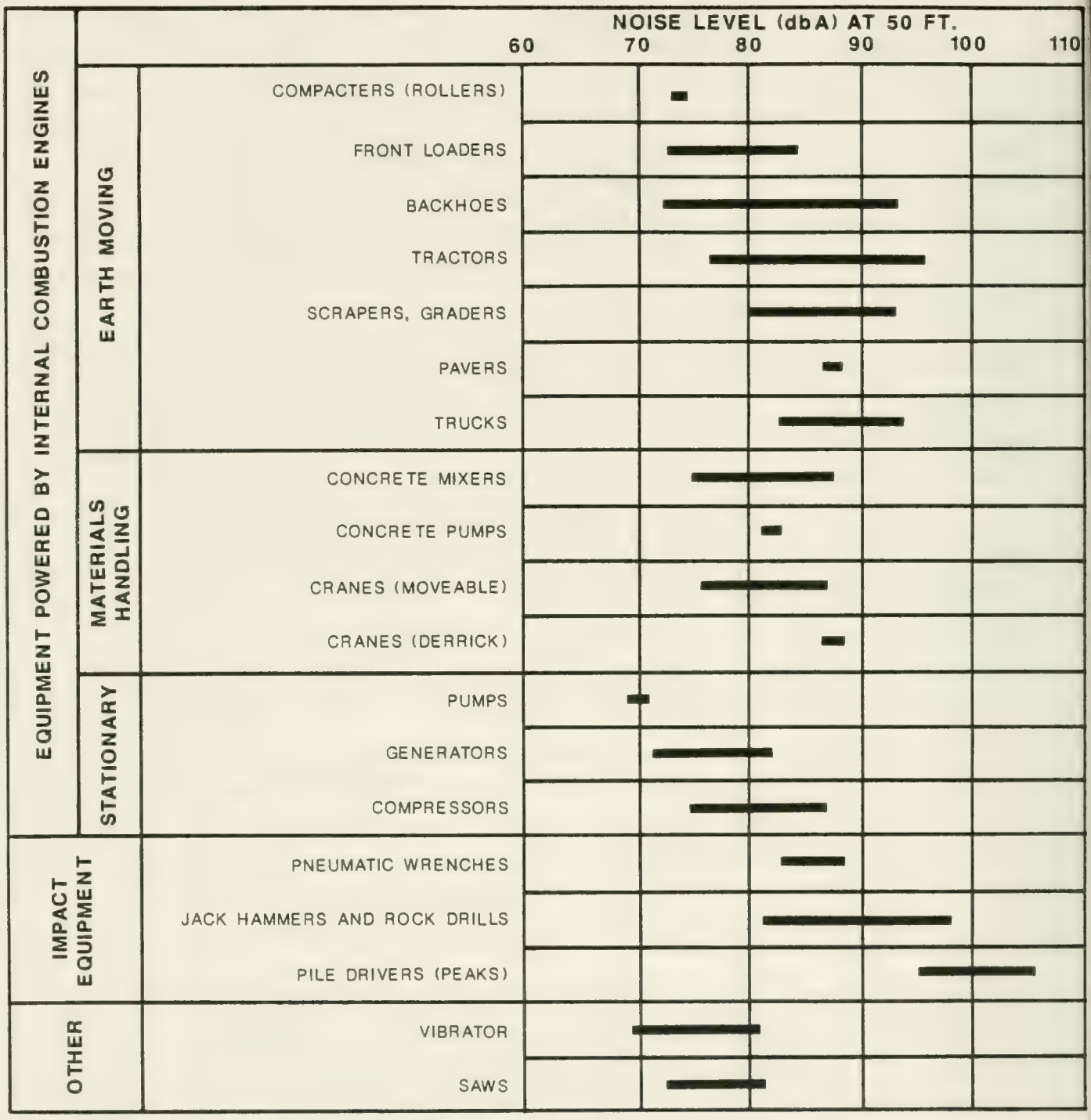
The U.S. Environmental Protection Agency (EPA) published an analytic noise model entitled "Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances" (U.S. Environmental Protection Agency, NTID 300.1, December 1971). The document estimates the level of exposure to construction noise, and is the basis for assessing the possible construction noise impacts associated with the 125 Summer Street Office Building.

In discussing noise levels, the common A-weighted decibel (dBA) was used for this study, since A-weighting refers to a standard frequency weighting which most accurately approximates human hearing and therefore allows correlation with annoyance levels, the major consequence of exposure to construction noise.

A number of different types of equipment are required during the construction process. Typical noise level ranges of construction equipment are outlined on Figure 4.6.1. The construction process can be separated into five distinct stages, each of which has its own mix of equipment and consequently its own noise characteristics. These stages are:

1) Clearing, demolition, or site preparation,
2) Excavation,
3) Foundation placement,
4) Frame erection, including floors, roof and windows
5) Finishing and clean-up.

The EPA model has combined the types of equipment and usage factor for each construction stage to calculate an estimate of the average noise level at 50 feet from the site's center during each stage. These average noise levels are presented in Table 4.6.1. Average noise levels are highest during excavation and clean-up assuming that all pertinent equipment is being utilized. The levels presented in Table 1 are average levels; at times noise levels will be higher and at other times lower. The average noise levels presented in this



NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES

From "Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances," U.S. Environmental Protection Agency, NTID 300.1, December 1971.

FIGURE 4.6.1 TYPICAL CONSTRUCTION EQUIPMENT NOISE RANGES

HMM Associates

TABLE 4.6.1

AVERAGE NOISE LEVELS AT CONSTRUCTION SITES*

Construction Stage	Construction Noise (dBA) @ 50 Feet	
	I	II
Clearing/Demolition	84	84
Excavation	89	79
Foundations	78	78
Erection	85	76
Finishing	89	76

I - All pertinent equipment present at site.

II - Minimum required equipment present at site.

* From "Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances," U.S. Environmental Protection Agency, NTID 300.1, December 1971.

table can be assumed to correlate reasonably with the L_{eq}, which corresponds to the equivalent sound level of all the time-varying sound levels, and is a good indicator of the effect of noise and people.

The EPA report also states that construction noise can be assumed to attenuate for a variety of reasons. For every doubling of distance a 6 dB reduction in noise is achieved. Furthermore, persons inside buildings will experience an additional 10* to 20 dB of reduction in noise depending on whether their windows are open or closed. For people inside cars with windows closed there is an attenuation of about 15 dB.

Two classes of people receive exposure to construction noise: 1) persons who live and work in the surrounding area and 2) drivers and pedestrians in the project area. The proposed 125 Summer Street Building project is in an area dominated by office buildings and commercial establishments. It is a very busy downtown business district with motor vehicle and pedestrian activity being the major contributor to local noise levels. Noise levels surrounding the site have been estimated to be in the area of about 75 dBA during periods of peak traffic volumes.**

There are two open areas in the vicinity of the site; one is on the northern side of Summer Street, between Atlantic Avenue and Purchase Street. This is a paved open and landscaped area with concrete benches. The other is directly across from the project site on the northern side of Summer Street. This is a small concrete bench area by the Blue Cross/Blue Shield Building. The two bench areas, which may be used for relaxation by persons employed in the area, are the most noise sensitive locations surrounding the project site.

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* Assumed based on field data collected by HMM in 1985.

** From "Traffic Noise Analysis for the Dewey Square Transportation Systems Management Program", HMM Associates, March 1984.

During construction of the 125 Summer Street Building, persons at the bench area immediately across from the project will experience construction noise levels ranging from about 68 dBA to 79 dBA, depending on the stage of construction. These levels assume that the maximum number of pertinent equipment is present at the site. If instead only the minimum required equipment is present, noise levels during the noisiest stage of construction may be reduced by 5 dBA to about 74 dBA. Persons at the bench area between Atlantic Avenue and Purchase Street are at a greater distance from the project site, and would experience noise levels between 60 dBA and 73 dBA depending on the amount of equipment used during each construction phase. The highest noise levels (71 dBA to 84 dBA) during construction activities would be realized by pedestrians walking immediately across from the site on Lincoln Street by the Surface Artery, although this level of noise exposure would be only temporary. It must be pointed out that the noise exposure levels for pedestrians depends on their position relative to the construction activity and that the levels presented in this study represent the worst case, in other words, the point at which the pedestrian is closest to the site. On the other hand, workers inside buildings along Lincoln Street and Summer Street should not be impacted, being exposed to considerable less construction noise due to the increased attenuation achieved with the building's walls.

The city of Boston has noise regulations for construction activity stating the maximum allowable noise levels at the lot line to various land uses. These regulations are summarized on Table 4.6.2. The maximum noise level that may be exceeded 10% of the time is 80 dBA at the affected property line in an area such as 125 Summer Street. It must be noted that the City's noise restriction levels do not include impact devices, which can be the noisiest equipment used at a construction site.

Pedestrians adjacent to the construction area may experience annoying noise levels as they pass the site, which

TABLE 4.6.2

CITY OF BOSTON

SUMMARY OF RESTRICTION ON CONSTRUCTION SITE NOISE*

3.1 MAXIMUM LEVELS

Land Use of Affected Property	Maximum Noise Level Value Measured at Lot Line of Affected Property (dBA)	
	L_{10}	Maximum Noise Level
Residential or Institutional	75	85
Business or Recreational	80	--
Industrial	85	--

(To be evaluated at distances not closer than 50 feet from nearest active construction device, using slow response of sound level meter.)

3.4 Maximum levels under 3.1 do not apply to impact devices (pile drivers, paving breakers, riveters, etc.)

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* City of Boston Air Pollution Control Commission, "Regulations for the Control of Noise in the City of Boston." Regulation 3, effective January 1, 1976.

would be gradually reduced as they walk away from the site. Persons resting on the concrete benches across from the site would also experience high noise levels, although not considerably higher than the 75 dBA that already exists in the area. The noisy urban environment that presently exists in the project area would, at least in part, mask the temporary increased noise levels during construction at the site. Persons inside buildings should not be significantly affected by construction activities at all.

There are a number of measures which could be taken to mitigate noise at the 125 Summer Street construction site, including:

- Use of appropriate mufflers.
- Installing enclosures around the work area where stationary equipment is being used.
- Replacement of individual operations and techniques by less noisy ones - e.g., using welding instead of riveting and mixing concrete offsite instead of onsite.
- Selecting the quietest of alternate items of equipment - e.g., electric instead of diesel-powered equipment, hydraulic tools instead of pneumatic impact tools.
- Scheduling of equipment operations to keep average levels low, to have noisiest operations coincide with times of highest ambient levels, and to keep noise levels relatively uniform in time.
- Turning off idling equipment.
- Keeping noisy equipment as far as possible from site boundaries.

With the use of appropriate mitigative measures at the work site, a reduction in construction noise levels of 5 to 10 dBA can be achieved.

4.7 HISTORIC QUALITY IMPACTS

4.7.1 Project Area

The project area consists of nine commercial buildings at the north end of an irregularly shaped block bounded by Summer Street (north), South Street (east), Lincoln Street (west), and a surface road above the Southeast Expressway (south). Prior to construction of the Southeast Expressway, the project area was part of a larger block of row buildings that extended without interruption southward to Essex Street. Buildings that currently stand within the project area are:

115-117 Summer Street - (1873), Alexander Esty, architect; storefronts 1939 and 1956) - a five-story Victorian Gothic style commercial building faced with sandstone on its two exposed elevations;

119-121 Summer Street - (1873-1875; storefront rebuilt ca. 1910 and 1962) - a five-story Second Empire style commercial building with added cast-iron facings at the first two stories (ca. 1910), original marble facings at the third and fourth stories and galvanized sheet metal at the mansard;

123-129 Summer Street - (structure built 1873; upper floors removed and facade rebuilt 1940) - a two-story commercial building faced with terrazzo panels.

131-135 Summer Street - (1873-1877; storefronts 1944 and ca. 1970) - a four-story commercial building with a marble-faced Italianate/Second Empire style facade;

137-139 Summer Street - (1873-1877), attributed to Ware & Van Brunt, architects; storefront 1923 and ca. 1970) - a five-story commercial building with two Second Empire style elevations faced with red brick and rock-faced granite;

16-18 Lincoln Street - (ca. 1880-1890) - a five-story commercial building with a face of cast iron and galvanized sheet metal; this structure serves as a rear wing to 119-121 Summer Street to which it is connected:

20 Lincoln Street - (1915) - a five-story commercial building with a narrow two-bay facade constructed of red brick and terracotta with Renaissance Revival style details;

22-34 Lincoln Street - (1885, George Pope, architect; storefronts altered 1943) - a five-story commercial building divided into two units by an interior party wall; the facade is faced with buff sandstone bearing simple Victorian Gothic style ornamental details.

15-17 South Street - (ca. 1880-1900?; facade rebuilt ca. 1922 and ca. 1970) - a five-story commercial building the facade of which has been re-faced with buff brick and limestone trimmings during the early twentieth century and with terracotta at the first two stories during the mid-twentieth century. This building stands outside the boundaries of the proposed Commercial Palace District from which it was excluded for a lack of architectural integrity and historical associations.

All buildings within the project area have been surveyed by the Boston Landmarks Commission as part of its Central Business District Preservation Study. None has been classified as either Category I (Highest Significance) or Category II (Major Significance). Buildings at 115-117, 131-135, and 137-139 Summer Street are noted as Category III (Significant) buildings.

Of the nine buildings all but 123-129 Summer Street and 15-17 South Street (which stands outside the district) are designated as contributing structures with the National Register although none is individually eligible for National Register listing (see Commercial Palace District, #7 below).

4.7.2 Environs of Project Area

Historically, the project area stands at the eastern edge of Boston's commercial (retail district) near wholesaling and warehousing districts. The visual and physical continuity of the site with surrounding districts has been largely disrupted by modern intrusions. South and east of the project area historic street patterns have been disconnected by the Expressway and its ramps which also brought about the demolition of numerous blocks of commercial buildings and warehouses. North and east of the site, the historical context of the Commercial District has been largely eliminated by the replacement of nineteenth-century row buildings with modern high-rise office buildings (Fiduciary Trust Building on High Street, Blue Cross Building at 100 Summer Street and the Dewey Square Office Building). West of the project area, nineteenth-century street patterns remain in position as do a number of nineteenth and early twentieth-century commercial buildings interspersed with grade-level parking lots and one multi-story parking garage.

Within sight of the project area, the six properties and two districts are either listed in the National Register of Historic Places, eligible for listing in the National Register or have been designated city landmarks by the Boston Landmarks Commission:

1) South Station Headhouse (corner Atlantic Avenue and Summer Streets - National Register) - Built in 1896-1899 and altered by the removal of its flanking wings during the 1970s, South Station derives historical significance from its well-executed Classical Revival style design (Shepley, Rutan & Coolidge, architects; Norcross Brothers, builders), its historical associations with the development of passenger train lines and several innovations in the planning of railroad terminals. The scale of the building as well as changes in the surrounding area leave it as a free-standing monument that is visible but separated from the project area by a high-rise office building (Dewey Square Tower) and the Southeast Expressway.

2) Russia Wharf Buildings (518-540 Atlantic Avenue and 270-290 Congress Street - National Register) - Built in 1897-1898 and designed by different architects for the same owner, the Russia Wharf Buildings consist of three seven-story structures that derive historical significance from their Classical Revival style architecture and their associations with the continuous commercial use of the Russia Wharf from the eighteenth century. Separated from the project area by the Southeast Expressway and the high-rise Federal Reserve Bank Building, the Russia Wharf is only partially visible from the project area.

3) United Shoe Machinery Building (140 Federal Street - Boston City Landmark and National Register) - Built in 1929 as one of the city's largest skyscrapers from plans by Parker, Thomas & Rice, the United Shoe Machinery Building is significant both for its historical associations with Massachusett's extensive shoe industry and for its elaborate Art Deco design,

ziggurat massing and well-preserved architectural detail. The building is oliquely visible from the project area from which it is saparated by several high-rise office buildings (Fiduciary Trust Building and 155-163 Federal Street).

4) Church Green Building (101-113 Summer Street - Boston City Landmark; eligible for National Register listing within the Commercial Palace District [see #7 below]) - Built immediately after the Great Fire of 1872, the Church Green Building contains two five-story structures that occupy a trapezoidal lot. The building's Second Empire style designs are associated with locally prominent architects and are characteristic of buildings constructed in the Commercial Palace District in 1873-1874. The Church Green Building faces the northwest corner of the project area.

5) Bedford Building (89-103 Bedford Street - National Register) - Built in 1874 and designed by Cummings & Sears, the Bedford Building is signifcant primarily for its elaborate Victorian Gothic design and its polychromatic stonework. Although built to the same five-story height as neighboring buildings in the Commercial Palace District, the Bedford Building stands apart from its neighbors in the individuality of its design. The Bedford Building faces the west side of the project area.

6) Proctor Building (100-106 Bedford Street - Boston City Landmark; eligible for National Register listing within the Commercial Palace District [see #7 below]) - Built in 1897 and designed by Winslow & Wetherell, the Proctor Building is an elaborately decorated example of Spanish Renaissance Revival architecture.

Of smaller scale and more modern materials (terracotta) than surrounding commercial buildings, the Proctor Building's major significance is derived from its design and well-preserved details. The building is obliquely visible from the project area from which it is separated by row buildings and a high-rise office building (99 Summer Street) that is now under construction.

7) Commercial Palace District (addresses on Bedford, Chauncy, Devonshire, Franklin, Hawley, Lincoln and Summer Streets - determined eligible for National Register listing) - The Commercial Palace District is an irregularly shaped area that contains 60 commercial buildings constructed shortly after the Great Fire of 1872 destroyed a large portion of Boston's business district. In the reconstruction that followed the fire, the majority of the district was developed with masonry row buildings constructed to five- and six-story heights with mansard roofs. Ornamentation was limited to facades that were frequently faced with sandstone, marble or granite in a variety of mid-Victorian architectural styles. The project area stands within the boundaries of the Commercial Palace District, at the district's extreme southeast end.

8) Leather District (addresses on Atlantic Avenue, Beach, East, Essex, Kneeland, Lincoln, South, Tufts and Utica Streets - National Register) - The Leather District occupies a grid of streets that is separated from the rest of the city's commercial district by the Southeast Expressway (west and north), railroad sidings (east) and undeveloped land with highway ramps (south). The district is significant both for its associations with Boston's large shoe

manufacturing and leather wholesaling industries and for the high architectural quality of its masonry row buildings, the majority of which were constructed in the 1880s and 1890s. The Leather District is visible from the south side of the project area.

4.7.3 Impact of Project

1) Primary Impact

The primary impact of the project will occur within the block that constitutes the project area where selective demolition and new construction will take place. The following actions are proposed:

- Five structures will be demolished. Of these, two (15-17 South Street and 123-129 Summer Street) possess no historical significance either individually or within the context of the proposed Commercial Palace District. The three other structures proposed for demolition (16-18, 20 and 22-34 Lincoln Street) are designated as minor contributing buildings to the Commercial Palace district; none is individually eligible for National Register listing or designation as a city landmark.

- Four structures will be retained and incorporated into new construction on the site. These four buildings include 115-117, 119-121, 131-135, and 137-139 Summer Street of which all but 119-121 Summer Street are designated as Buildings of Significance to the City within the proposed Commercial Palace District. In order to incorporate these buildings into new construction, their rear elevations and wood floor framings will be removed; facades and mansard roofs will be retained.

Various aspects of the project have been planned to mitigate the effect of new construction on historic resources within the project area; these are:

- The project area's four most historically significant buildings will be retained. These buildings form the property's Summer Street frontage and include corner buildings with finished elevations that wrap around the site to South and Lincoln Street.

- The four buildings to be retained will undergo the restoration of their facades; to the extent possible, restoration will seek to restore the original appearance of each building based on documentary evidence. In cases such as 119-121 Summer Street where major portions of the original facade were removed and substantially rebuilt in the early twentieth century, restoration shall seek to restore the building to its early twentieth-century appearance.

- Demolitions within the site are limited to minor buildings along its south side where the site has already been disrupted by the construction of the Southeast Expressway. Along Summer Street, demolition is limited to a two-story structure that does not contribute to the significance of the site's nineteenth-century buildings.

- New construction on the site will consist of a five-story base that extends out to the sidewalk along Summer, South and Lincoln Street. The height of this base will match the height of existing buildings along the Summer Street side of the site. The height and massing of the base have been selected to provide an appropriate context for the four

remaining row buildings. In addition, new floor levels have been planned to correspond to existing window heights along Summer Street. A high-rise office building will be built near the center of the site with deep recesses back from the building's five-story base.

- New construction will be faced with stone masonry materials bearing ornamental articulation at entries, windows and cornices to provide an appearance that relates to the four remaining buildings on the site.

2) Secondary Impacts

As construction will be limited to the project area and is not part of a larger plan requiring the construction of streets or surrounding blocks, the project will have no direct effect on nearby historic properties. Its principal effect on such properties will be visual; the importance of this effect will vary with distance from the project area. In the case of properties such as the Russia Wharf Buildings, the South Station Headhouse and the United Shoe Machinery Building, visual effects represent a negligible impact, as all three properties stand in relative isolation, separated from the project area by numerous large-scale modern intrusions. Similarly, the project's visual impact on the Leather District is negligible due to the district's isolation and self-contained setting.

The impact of the project upon the Church Green Building, the Bedford Building, the Proctor Building and the Commercial Palace District are relatively greater due to proximity. As the project area stands at the extreme southeast corner of the district and is only obliquely visible from the Proctor Building, its visual impact is relatively minor except in relation to the Church Green

Building and the Bedford Building which it faces. Several aspects of the project have been planned to mitigate the effect of new construction on the setting of these two buildings, namely, the construction of a five-story base that fills in the holes of the existing row buildings along Summer and Lincoln Street, the use of stone facings with ornamental articulation on new construction and the restoration of four facades within the project area to strengthen the historic character of the intersection at Church Green.

4.8 UTILITY SYSTEMS IMPACTS

4.8.1 Sewer System for 125 Summer Street Site

The City of Boston has a public sewer system that is operated by the Boston Water and Sewer Commission (BWSC). Throughout most of the downtown and financial districts of the city, service consists of combined sewers. Sanitary wastewater and storm water from the existing buildings in the vicinity of Summer Street are collected by combined sewers and directed to the East Side Interceptor (ESI). The ESI passes close to the site and conveys the wastewater to the new Boston Main Interceptor (BMI), and then on to the Massachusetts Water Resources Authority (MWRA) Deer Island Treatment Plant. At Deer Island the wastewater currently receives primary treatment and chlorination before being discharged to Boston Harbor.

The present sewer system serving the site area is shown on Figure 4.8.1.

4.8.2 Sewer System - Site to East Side Interceptor

The project site is served by sewer lines on Summer Street, Lincoln Street and the Surface Artery. Both Summer and Lincoln Streets are served by a 24" x 28" egg-shaped combined storm and sanitary sewer. The line that runs parallel to the Surface Artery is 48" and is close to the building site due to the underground expressway and ventilation stack. All three lines converge at Dewey Square and eventually lead to the ESI via a 72" diameter sewer. A regulator in the conduit at this location discharges all dry weather flow into the ESI. Excess wet weather flow overflows the regulator, bypasses the ESI and is discharged into Fort Point Channel just south of Northern Avenue at outfall BOS-062. Figure 4.8.2 illustrates the operation of a typical regulator during storm flow situations.

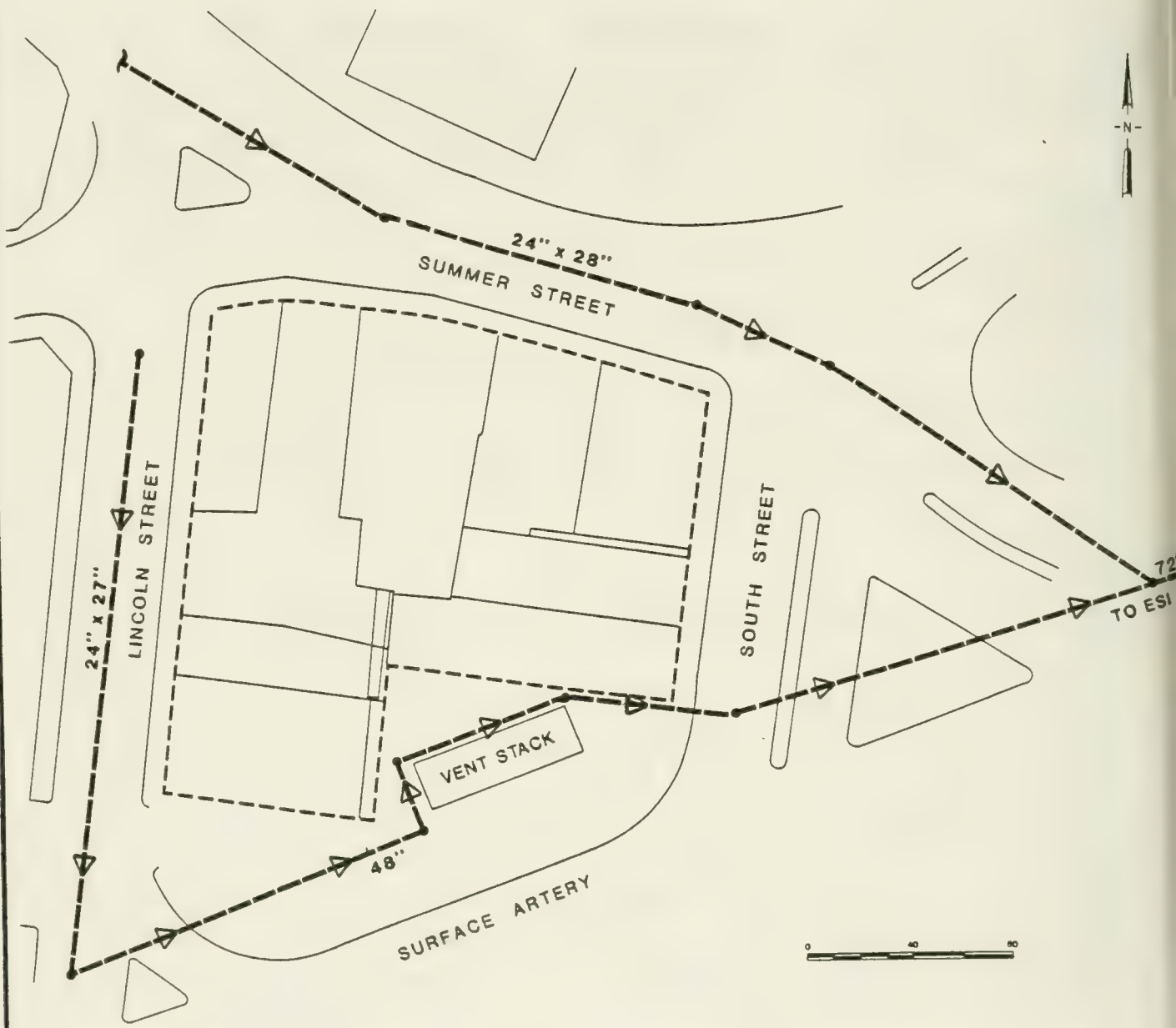
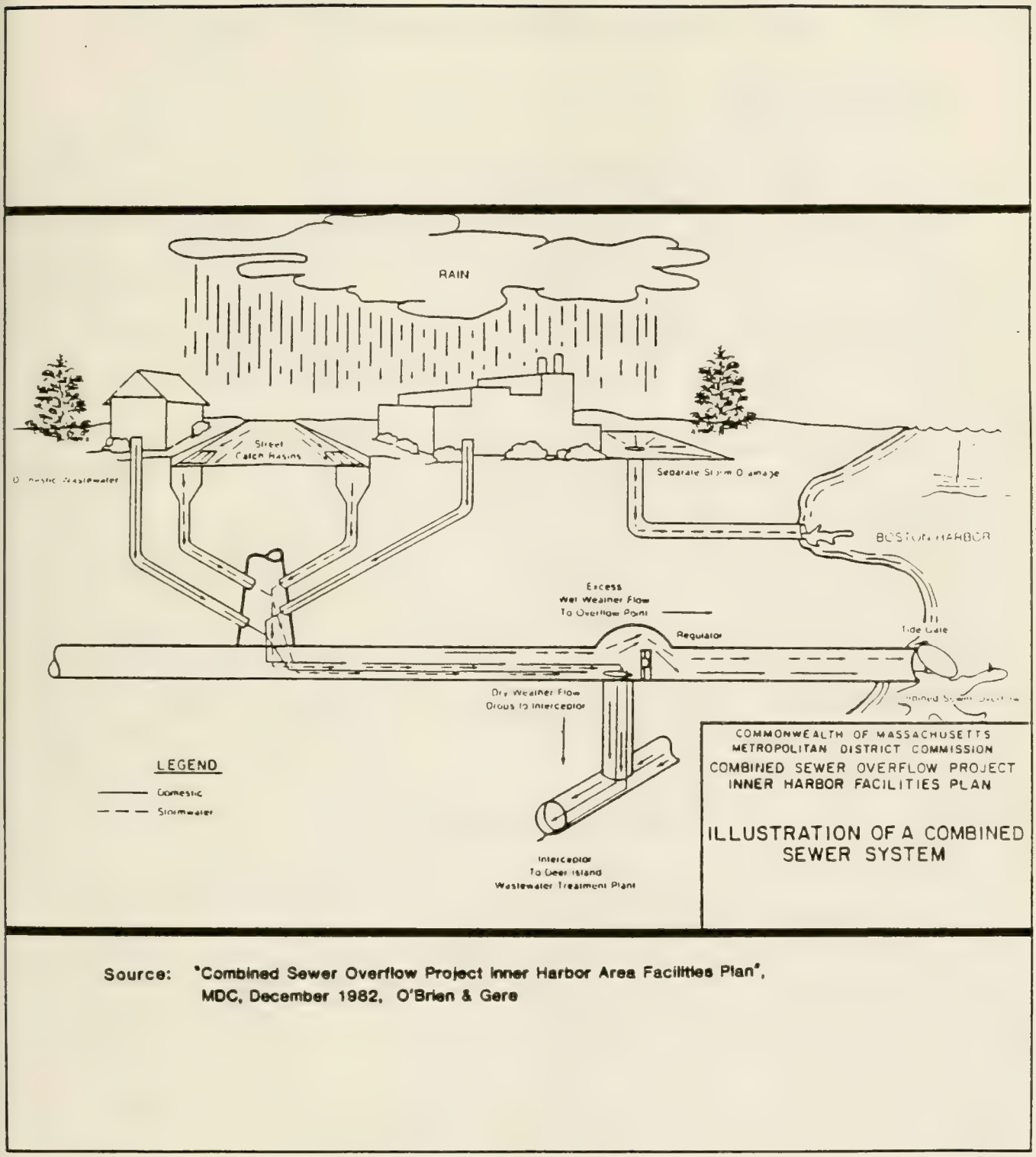


FIGURE 4.8.1 SEWER SYSTEM AT 125 SUMMER STREET SITE



Source: "Combined Sewer Overflow Project Inner Harbor Area Facilities Plan", MDC, December 1982, O'Brien & Gere

FIGURE 4.8.2 TYPICAL COMBINED SEWER SYSTEM

4.8.3 Sewer System - East Side Interceptor to Deer Island

Existing System

East Side Interceptor

The ESI conveys dry weather flows and some wet weather flows from the downtown financial district, the Waterfront area, the North End and portions of the South End, to the new BMI at the south end of the South Station Railroad Yard.

The ESI begins at Hanover Street in the North End and continues to the south along Commercial Street and then along Atlantic Avenue south to Beach Street. It then proceeds south, under the South Station Railroad Yard to the BMI.

The portion of the ESI north of the site from Eastern Street to Harbor Towers was replaced as part of the Waterfront Park Project. The BWSC has initiated action to replace the remainder of the ESI. At this writing, the BWSC has completed a section from the south end of the South Station Railroad Yard to Kneeland Street. The entire replacement, through the Rowes Wharf area, is expected to be complete in about 2-3 years.

Boston Main Interceptor

In the new BMI, sewage generally flows from north to south through the southern part of Boston. The BMI serves to convey flows from the other Boston interceptors (including the ESI) to the junction with the MWRA system at the Columbus Park Headworks.

The new BMI is a complete replacement of the old BMI, which previously served the same major interceptors. Sewage in the new BMI flows from the south end of the South Station Railroad Yard to Andrew Square in a 9,000 square foot section of pipe completed in September, 1986. Flow from Andrew Square to the Columbus Park Headworks is in a 2,650 foot section of pipe completed in May, 1984.

MWRA Tunnel to Deer Island

Wastewater collected in the BWSC's system enters the MWRA system at the Columbus Park Headworks which has a capacity of 180 million gallons per day (MGD). Average dry weather flow to the headworks is approximately 64 MGD. The MWRA Tunnel which conveys sewage from the Columbus Park Headworks to the Deer Island Treatment Plant has a peak capacity of 440 MGD.

Plans for System Improvements - East Side and Boston Main Interceptor Replacement

Most water quality problems in the Inner Harbor can be significantly reduced if dry weather overflows are eliminated and if wet weather combined sewer overflows (CSO) are minimized. Currently, the MWRA and the BWSC are working on elements of a Recommended Plan for CSO control. The plan is intended to eliminate dry weather overflow by in-system modifications to tidegates and regulators, by improvements in collection capacity (e.g., new ESI) and by continuing inspection and maintenance programs. The plan also calls for reductions of up to 75% in the frequency and volume of CSO. The goal is to provide treatment for all storms with a probability of occurring less than once per year with a six hour duration.

In conjunction with this plan, the BWSC has initiated a $60 million design and construction program to replace major sewer interceptor pipes. The program is designed to eliminate dry weather overflows caused by insufficient capacity in the existing systems and to provide replacements where the system has deteriorated.

Plans for System Improvements at Deer Island Treatment Plant

The MWRA is currently in the process of upgrading the Deer Island Treatment Plant in two stages. The first stage is an immediate upgrade to improve pumping capacities at the plant. This program is intended to prevent situations where failure of pumping equipment at Deer Island leads to increased discharges at CSO facilities and the Moon Island outfall. This stage is intended to be complete by 1988.

The second stage is a complete construction of a new facility to upgrade treatment capability. A design contract for the treatment plant upgrade was recently awarded by MWRA. Parallel efforts are underway to design and provide an adequate site for the required sludge management facilities. This program will extend into the mid 1990's.

4.8.4 Project Sewer Connections

Requirements for Retention Tanks

The BWSC has initiated a number of recent actions to improve CSOs. The Commission has, since 1980, been conducting an ongoing inspection and maintenance program along the ESI and its associated CSO's. This program includes inspections and required maintenance of regulators and tidegates on a schedule of two times each quarter.

In addition to maintenance programs and periodic inspections underway since 1980, the BWSC requires the use of sewage retention tanks for all large developments in the area tributary to the ESI. These retention tanks are sized to collect an entire day's generation of sanitary wastewater from the building. This wastewater is then discharged during the two four-hour periods of the day when the tide is lowest. Surcharging in the sewer system often results from the tidal inflow during high tide periods. By discharging during low tide periods, the building minimizes the impact of its sewage on this tidal surcharging problem.

Sanitary and Storm Sewer Connections

As the design and plans for operation of the sewer system for the project is now in the conceptual phase, the proponent will work with the BWSC to resolve design issues. Discussions will be directed towards determining appropriate mitigation measures for use by the project in light of the current sewer capacity problems in the site area and to assure that the project is compatible with other recent activities in the area (e.g. the Rowes Wharf project).

Sanitary and storm water discharge will likely be connected to Summer Street or Lincoln Street sewers. As the design progresses, the project engineers will consult with the BWSC on the precise configuration of the connection.

4.8.5 Project Impact

As noted earlier, the proposed use at 125 Summer Street will be primarily office space of approximately 495,000 SF with minimal street level retail activity including restaurants with about 100 seats. It will replace existing office space of approximately 143,000 SF, and restaurants with about 150 seats.

Estimated Sewage Flow

1) Office Space: (495,000 SF proposed - 143,000 SF existing) x 75 gallons per day (gpd)/1,000 SF* = 26,400 gpd.

2) Restaurant: (100 seats proposed - 150 seats existing) x 35 gpd/seat* = -1,750 gpd.

Total Sewage Load: 26,400 gpd - 1,750 gpd = 24,650 gpd.

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* Per MA DEQE, Title 5, Sanitary Sewage Generation Factors (310 CMR 15.02).

The net additional sewage generation attributable to the proposed project is approximately 24,650 gpd.

Storm Water

The quantity of storm water for the site will remain essentially unchanged since the impervious area will not significantly change.

4.8.6 Mitigation Measures

Project-Specific

The following mitigation measures will be implemented by the project proponent.

1) Use of the latest, most efficient plumbing fixtures including limited flow faucets (.75 gallons per minute (gpm) vs 1.5 gpm) and toilets that require less water than the more conventional equipment, as required by the state plumbing code.

2) Use of a sewage retention tank with the capacity to store an entire day's sanitary wastewater. The tank will be equipped with a triplex pumping system and a programmable tide clock controller. Sanitary wastewater will be pumped into the combined sewer system only during periods of low tide. This will reduce loads on the system during high tide periods when surcharging caused by tidal inflow is a problem.

In addition to these measures, the proponent is prepared to operate the programmable pumping system on any feasible schedule proposed in the future by the BWSC . This could include time of day pumping to avoid peak daytime flow periods.

System-Wide Measures

Constraints imposed upon individual new developments can mitigate localized problems and can assist in achieving overall improvement to water quality in the Harbor. However, real improvement can only be made with large-scale efforts to upgrade the combined sewer system operation. The MWRA and BWSC are currently undertaking a number of such improvements:

1) Replacement of the ESI. This project will be completed by the end of 1989. It will increase the ESI capacity in the site area from the current 5-9 million gallons per day to 43 million gallons per day. It will eliminate the hydraulic constraint currently causing surcharging in the vicinity of Central Wharf (BOS-060). It is also expected to eliminate dry weather overflows and significantly reduce wet weather overflows at all the combined sewer overflow outlets that would be impacted by the project.

2) Inspection and maintenance of tidegates and regulators. The BWSC instituted a program to inspect all tidegates and regulators at least two times each quarter.

3) Completion of the Combined Sewer Overflow Recommended Plan. This comprehensive program includes the installation of new CSO treatment facilities for screening and disinfecting CSO discharges, replacement of tidegates and regulators, sewer separations, and storage facilites. The goal of this 10-year program is to eliminate dry weather overflows and reduce the discharge of untreated CSO by 75 percent.

Included in this program is the construction of the Fort Point Channel CSO Treatment Facility which will greatly reduce CSO pollutant discharges to Boston Harbor.

4. Upgrade Deer Island Treatment Plant pumping capacity and add secondary treatment capability.

4.8.7 Other Utilities

Water

The water distribution system in the vicinity of 125 Summer Street is shown on Figure 4.8.3. The existing system includes high pressure service lines for fire protection, and low pressure service lines for domestic water use. High pressure service mains include a 12" main on Summer Street, and 8" mains on South Street and Lincoln Street. There are existing fire protection connections onto the site from each of the three high pressure service mains.

Domestic water service is available from a 16" low pressure service main that runs along Summer Street, and a 12" main along Lincoln Street. Domestic water service for the project will be provided by connections to one or more of these mains.

Domestic water demand for this project is expected to total 44,700 gpd. In addition, air conditioning makeup water is expected to average 40,000 gpd. The peak domestic use is estimated at 70 gpm, based on a peaking factor of 3.0 for restaurants and 2.4 for offices. A peak air conditioning makeup water rate of 100 gpm is anticipated, resulting in a total peak demand of approximately 170 gpm.

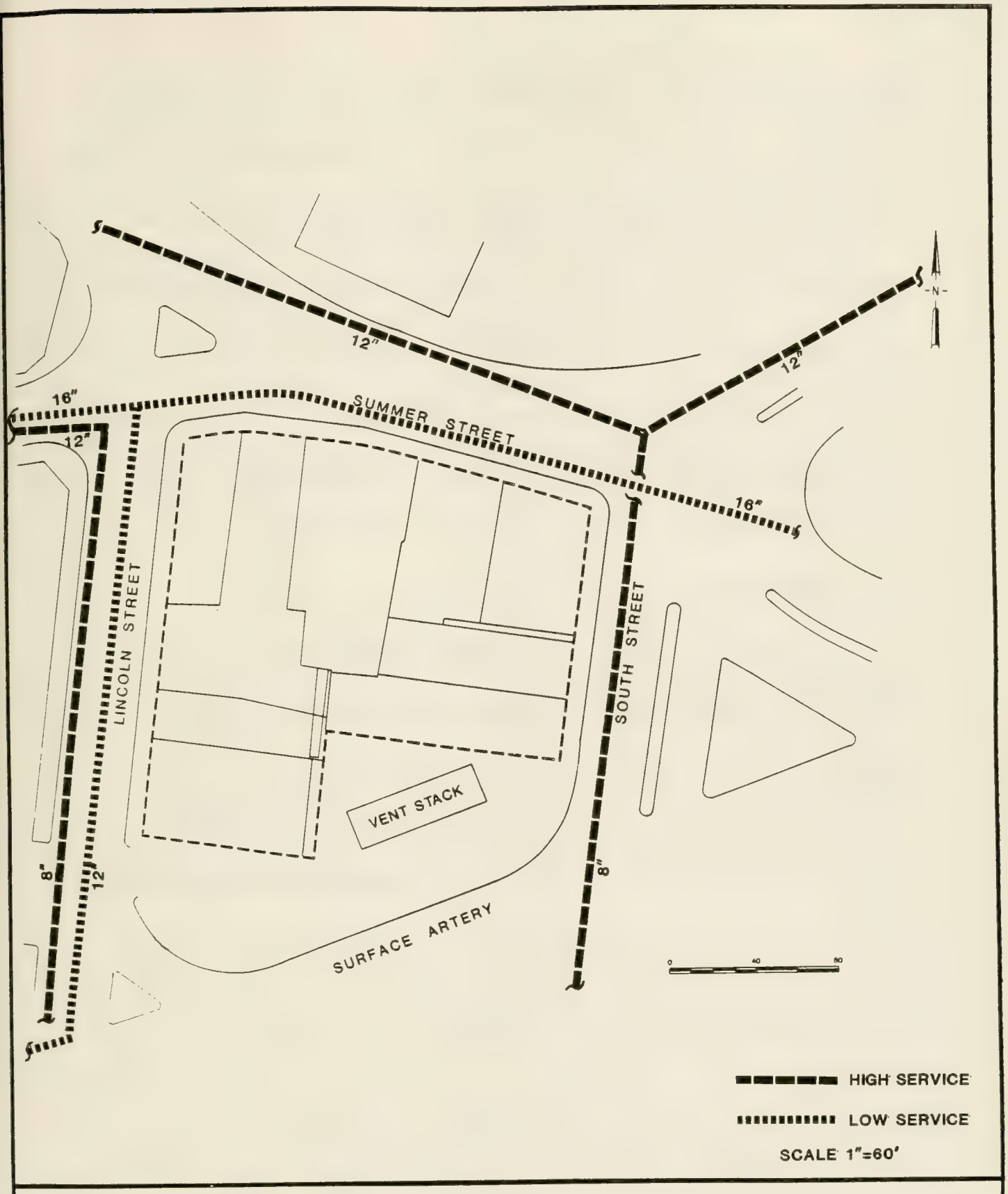


FIGURE 4.8.3 EXISTING WATER SYSTEM AT 125 SUMMER STREET SITE

To determine the capacity of the existing low pressure water service in the general site vicinity, a hydrant test was conducted at the proponent's request in October, 1986 by BWSC. The test was done on a 12" low pressure service main at Harrison Avenue in the vicinity of Oak Street and Hudson Street. This location was selected by the BWSC, and is considered representative of the project site area. The test indicated an available flow of 3,270 gpm at a satisfactory residual pressure of 50 psi. The results of this test indicate that the low pressure service system in the site vicinity has capacity to satisfy the project demand (peak flow of 170 gpm).

Existing fire protection connections at the site will be maintained and augmented as necessary to provide the necessary fire flow. Design of the fire protection systems will be coordinated with BWSC and the City Fire Department.

Solid Waste

With full occupancy of 125 Summer.Street, solid waste generation is estimated at about 2 tons per day (5 days per week). Solid waste will be disposed by private haulers (as is the case with office buildings in Boston). The solid waste will probably be disposed of in a commercial landfill or at the Saugus Resource Recovery Plant. By 1990, a large resource recovery plant will be constructed at the old city incinerator site which will have a capacity of at least 2,000 tons per day.

4.9 ENERGY IMPACTS

4.9.1 Introduction

Throughout the development of 125 Summer Street, energy efficiency has been a significant consideration. R. G. Vanderweil Engineers, Inc. the mechanical engineers for the project, have been charged with designing HVAC and mechanical systems that incorporate advanced technology in energy conservation technology. In addition to the requirements of the Massachusetts State Building Code Provisions for Energy consumption, and other accepted industry standards such as ASHRAE 90-75, the objectives of the energy design and analysis process has been:

- To minimize building energy demand
- To minimize wasteful elements of summer solar gain.
- To minimize fossil-fuel consumption
- To maximize energy efficiency based upon the anticipated life-cycle costs of the building energy systems.

4.9.2 Building Energy Conservation Measures

Window Design Treatment

Window design treatment was based on projected building use. Office use will be by far, the predominant use, with street level retail space. These uses will lead to heavy daytime usage with much less intense evening usage during hours of darkness.

In selecting windows, the architects and engineers have been sensitive to all energy issues. Accordingly, the windows will be double glazed and combine reflective coatings with some tinted glass panes. The double glazing doubles the R values over single glazed windows, conserving energy devoted to either space heating or air conditioning. The dual-pane reflective

glass also prevents excessive solar gain reducing air conditioning requirements, and contributing to sound insulation.

Thermal Insulation

The "skin" of the building will consist of the double glazed window, described above, and stone. A portion of each face would be a vertical bay window, providing a vertical emphasis to the design, reflecting earlier 19th and 20th Century commercial buildings.

4.9.3 HVAC Design Considerations

Past experience and feasibility studies have lead to the selection of the HVAC system for 125 Summer Street. Electric resistance was selected as the system that is being used more and more frequently in Boston's commercial developments. The selection of electric heat was based upon its demonstrated reliability, its lower capital cost, and its reduced space demands. Such systems have minimal maintenance problems. An all electric development will receive the benefits of a lower electric rate, not only for the space heating, but for total electrical consumption.

4.9.4 Characteristics of the Selected HVAC System

The all-electric HVAC system for 125 Summer Street consists of the electric resistance heating, a chilled water air-conditioning system, and a variable air volume (VAV) ventilation system.

Electric resistance heat will be supplied primarily via coils in the VAV system. Supplementary perimeter electric heating will also be provided and distributed overhead through a perimeter linear diffuser. In the office and retail spaces, all heat accumulated in the ceiling return-air plenums from lights and other electrical and mechanical systems will be circulated to heat the building perimeters.

Each floor will have a separate chilled water air-handling unit serving zoned VAV fan powered units for the floor areas on the building perimeter and VAV terminal units for the building interior floor areas. The VAV equipment balances the need for outside air with recirculated inside air. Outside air will be vertically distributed to the fan rooms on each floor.

A less energy intensive condenser water free-cooling system will be provided for a portion of the cooling season. The condenser water free-cooling cycle will save energy as refrigeration compressors can be shut down when outside temperatures in the spring and fall permit natural cooling. During these periods, chilled water will be obtained directly from the cooling towers without the use of mechanical refrigeration.

The zoned VAV system has distinct advantages over conventional HVAC systems. It provides for local climate control on demand. It incorporates natural heating and cooling by mechanically mixing and supplying air volumes to areas with heating or cooling requirements. The result is a HVAC system in which the relationship between building occupancy and climate control energy consumption are quasi-linear; that is, the system can respond efficiently to localized demands whether they be special type occupancy or just partial occupancy.

4.9.5 Lighting

The lighting for the building will consist primarily of overhead space lighting with a minimal amount of direct and indirect specialty lighting for special tenant needs and public areas. The space lighting will be provided by the newest high-efficiency parabolic-louvre light fixtures with high efficiency ballasts. These lights combine the high efficiency of fluorescent lighting with the no-glare diffusion of a parabolic reflector returning the "wasted light". This lighting system, in conjunction with the natural lighting, requires a low wattage per square foot to provide a comfortable lighting level.

All space lighting will be activated by local switching systems on a room-by-room basis.

4.9.6 Total Energy Demand

Since 125 Summer Street is an all-electric design (with an emergency back-up generator) its energy consumption is measurable. The estimated total annual energy consumption is 8 watts/square foot or 3,920,000 watts in total. A breakdown of the total expected energy use is provided in Table 4.9.1. As shown in the table, lighting, appliances, cooling, heating and air handling are the major energy consuming activities.

TABLE 4.9.1
125 SUMMER STREET
ESTIMATED ELECTRICAL CONSUMPTION

Project Component	Annual Consumption Watts
Lighting	2.5
Heating/Cooling	2.5
Miscellaneous Office Power	1.0
Supplementary Lighting	1.0
Supplementary Power For Special Equipment	1.0
Total	8.0

4.9.7 Conclusions

The 125 Summer Street mechanical systems are well designed and energy efficient. The major energy consuming facilities that have been chosen is a coordinated all-electric design that exceeds accepted building codes and industry standards for energy efficiency.

4.10 NATURAL RESOURCES IMPACT

4.10.1 Sub-Soil Conditions

Subsurface conditions and preliminary foundation design recommendations were prepared by Haley & Aldrich, Inc. in July and August, 1985. The following are based on the information gathered to determine existing site conditions and subsurface conditions: Elevations referenced herein are Boston City Base.

A. Site Conditions

Major below-grade structures in the immediate vicinity of the site include the following:

- The John F. Fitzgerald Expressway tunnel is located south of the site directly beneath the Surface Artery. Top of existing tunnel ranges from El. 17 to El. 15.5. The tunnel is soil-bearing from El. -6.5 to El. -9.0, sloping downward from east to west in the area of the site.

- A ventilation stack associated with the Expressway tunnel is located between the site and the Expressway tunnel. Available information indicates that the structure is bearing on a 5-ft. thick concrete mat foundation at approximately El. -7.

- The MBTA Red Line Tunnel is located north of the site directly beneath Summer Street. Available drawings indicate that the tunnel invert ranges from El. -27.5 to El. -22.5 with elevation decreasing from west to east.

- A 48-in. diameter reinforced concrete pipe sewer is located parallel and north of the existing Expressway tunnel. Refer to Site Plan prepared by Harry R. Feldman, Inc. The sewer invert ranges from approximately El. 4.5 to El. 5 near the site as the sewer passes between the site limits and the Expressway tunnel and ventilation stack as shown in Section on Figures 4 and 5.

  Information gathered on utilities near the site indicates that numerous utilities are present directly below the streets bordering the site.

  A utility profile at the north wall of the Expressway tunnel at the South Street intersection indicates utilities along the Surface Artery and along South Street between approximately El. 23 and El. 18 (approximate top of Expressway tunnel roof). As previously mentioned, a 48-inch diameter storm sewer (invert El. +4.5) is indicated with an alignment parallel to the Expressway tunnel.

  A utility profile at the intersection of South Street and Summer Street indicates numerous utilities between approximately El. 23 and El. 4.5, including several storm sewer lines between approximately El. 15.5 and El. 4.5. The MBTA Red Line tunnel roof is shown at El. 1.0. A utility profile was not found along Lincoln Street, but based on the site plan and field experience, a 20-inch diameter high pressure water main is known to be located approximately three feet from the existing curb at a depth of approximately 7 ft.

Based on the information gathered, it appears that the concentration of utilities is greatest along Summer Street and then South Street and probably to a lesser degree along Lincoln Street and the surface artery. It is not known whether any utilities traverse the site.

B. Subsurface Conditions

The subsurface soils at the site reflect the successive effects of glaciation, a subsequent estuarine environment and various phases of man-placed filling and development. Figure 4.10.1 depicts the four test borings.

Generalized descriptions of the soils, as encountered from ground surface at the locations of the test borings, are given below:

- Fill - Fill was encountered in each test boring, ranging in thickness from 4 to 5 feet below sidewalk vault slabs and 8 to 11 feet below outside existing ground surface. Fill encountered below the vault slab-on-grade in borings B1 and B2 consisted of silty yellow clay, trace gravel and brick. Fill encountered in borings B3 and B4 consisted of coarse to fine sand, little gravel. These borings were probably within the backfill zone of the ventilation shaft for the Expressway tunnel.

- Clay - A stratum of silty clay was encountered below the fill at each boring location. The clay ranged in thickness from 24 feet at boring B1 to 5.5 feet at boring B3. The composition of the stratum varies from:
  - very still yellow clay, trace to little gravel; usually appearing in the upper 5 to 10 feet of the clay stratum, to stiff to very stiff gray silty clay.

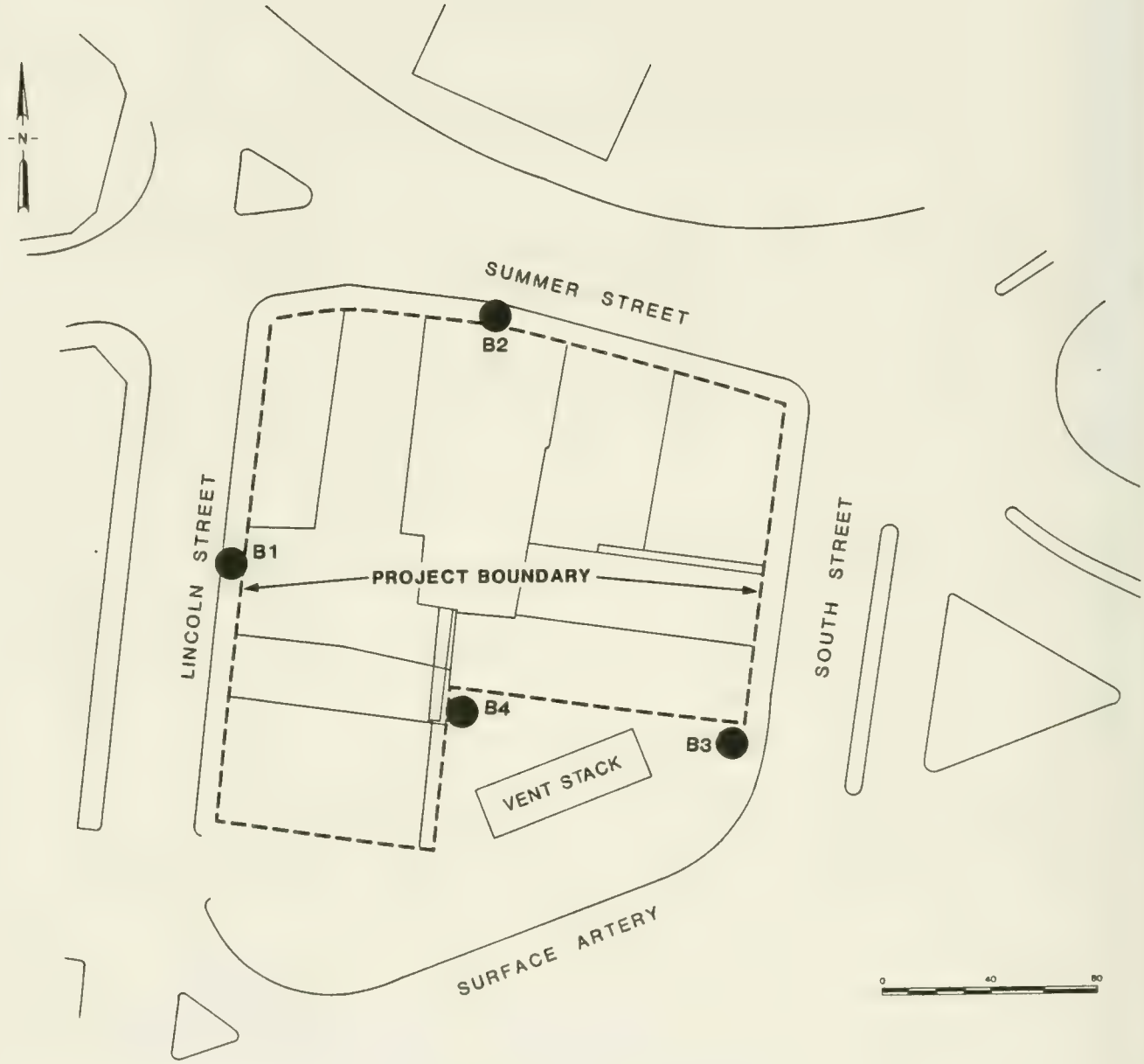


Figure 4.10.1 Location of Test Borings

- stiff to very stiff gray silty clay.

Boring B1 encountered a 4-ft. thick layer of silt to fine silty sand with interbedded clay between the upper yellow clay and the silty gray clay.

Boring B3 encountered a 6-ft. thick layer of sandy silt between the clay and the glacial till below El. 8.

o Glacial Till - All borings were terminated in the glacial till stratum. borings were advanced 23.5 to 30.5 feet below the top of the glacial till.

The composition of the glacial till was variable, generally ranging from a:

- silty CLAY with little gravel and coarse to fine sand to a

- coarse to fine sandy CLAY, little coarse to fine gravel.

Boring B2 encountered glacial till composed of a silty medium to fine SAND to fine sandy SILT from El. -11 to the bottom of the borehole at El. -23.

The top of the glacial till generally dips from north to south and from east to west. the top of glacial till elevation is shown on Figure 2.

Two test borings, B3 and B4, noted a 2 to 4-ft. thick sand layer within the glacial till at a depth of approximately 39 feet, (El. -14).

Bedrock was not encountered in any of the test borings.

The latest groundwater level readings in the observation wells range between El. 5.4 and El. 13.1. The groundwater levels in wells B1, B3 andB4, located to the south of the site, range from El. 5.4 to El. 7.1. Higher levels are present in well B2 located at the north end of the site. Typical groundwater levels in the area generally average near El. 8. The groundwater levels in wells B1, B3 and B4 may be slightly depressed due to the permanent dewatering system for the Expressway tunnel. The higher groundwater level in well B2 may not have stabilized as of the latest reading or represent a perched condition.

4.10.2 Excavation and Foundation Construction - Potential Impacts

Foundation requirements will support a 22-story structure with three (3) to five (5) levels of below grade parking. With 5 levels of parking the lowest level will be at about 58 feet below the street level. It is recommended to support the building columns on individual spread footings or a mat foundation bearing on the glacial till. A laterally braced concrete diaphragm/slurry wall is anticipated for lateral support of the excavation and the permanent foundation wall.

A. Hydrostatic Design

Water levels at the site are slightly depressed due to the permanent dewatering system for the Expressway tunnel beneath the Surface Artery. The present groundwater table declines across the site from approximately El. 13 along Summer Street to El. 6 adjacent to the Surface Artery, based on the observation well readings.

For the design of the lowest level slab, it should be assumed that hydrostatic pressures will act beneath the slab and against the walls even though site water levels may be depressed by the Expressway dewatering system, and possibly by the MBTA

Red Line tunnel and by local storm sewers with deep inverts. Evaluations of hydrostatic pressure should not rely on continued groundwater depression by the Expressway tunnel drainage system or by other subsurface structures. With use of a concrete diaphragm wall it will be possible to provide a permanent system for full relief at hydrostatic pressures for the lowest level floor slab. The wall would be extended 10 to 15 feet below the lowest floor level to serve as a permanent seepage cutoff. The permanent seepage cutoff is required to preclude draw down of normal groundwater levels in the area.

B. Seismic Considerations

1. Soil "S" Factor - All foundations will be designed in accordance with the current Massachusetts State Building Code. For seismic considerations, all natural soils below the fill may be considered Class A materials. Therefore, a soil factor "S" of 1.0 (refer to Section 716.9 of the Code) would be appropriate.

2. Lateral Earth Pressure - During an earthquake occurrence, additional stresses will develop against the exterior basement foundation walls of the structure. The exterior foundation walls below grade will be designed to resist an earthquake force calculated in accordance with Section 716.6.10 of the Massachusetts State Building Code.

C. Liquefaction Considerations

The Massachusetts Building Code, Section 720.4, provides criteria with which to evaluate the liquefaction potential of saturated fine granular materials. The term "liquefaction" describes a phenomena in which a saturated cohesionless soil loses its strength during an earthquake and may result in substantial settlement.

Based on evaluations of the preliminary soil data obtained at this site, it is concluded that the subgrade soils below the recommended bearing level would not be susceptible to liquefaction.

4.10.3 Construction Impacts

A. Excavation

Foundation construction for five levels below grade will require an excavation of 55 feet.

The site is presently occupied by structures which are supported on spread footings at relatively shallow depths.

The clay and glacial till soils which will be exposed at the excavation level are sensitive to disturbance. Accordingly, after excavation to foundation level, a nominal 2 or 3-inch thickness of lean concrete will be placed over the mat foundation bearing surface to serve as a working mat.

B. Lateral Support

A concrete diaphragm wall is utilized as the temporary lateral earth support and incorporated into the permanent basement wall.

The concrete diaphragm wall will be braced using internal and external bracing.

Internal bracing will be utilized where external bracing is not possible due to the presence of the subsurface structures.

Internal bracing consists of corner braces, cross-lot and inclined rakers. External bracing is drilled in earth tiebacks. External bracing extends beyond the limits of the excavation, internal bracing is within the excavation.

Approximately four levels of bracing is anticipated.

C. Dewatering

Based on the observed water levels, the excavation will extend approximately 35 to 40 feet below the present groundwater levels at the site.

A slurry wall system will be effective as a seepage cutoff and would reduce the dewatering requirements during construction.

In general, it is anticipted that excavation dewatering may be achieved by open pumping within the excavation.

APPENDICES

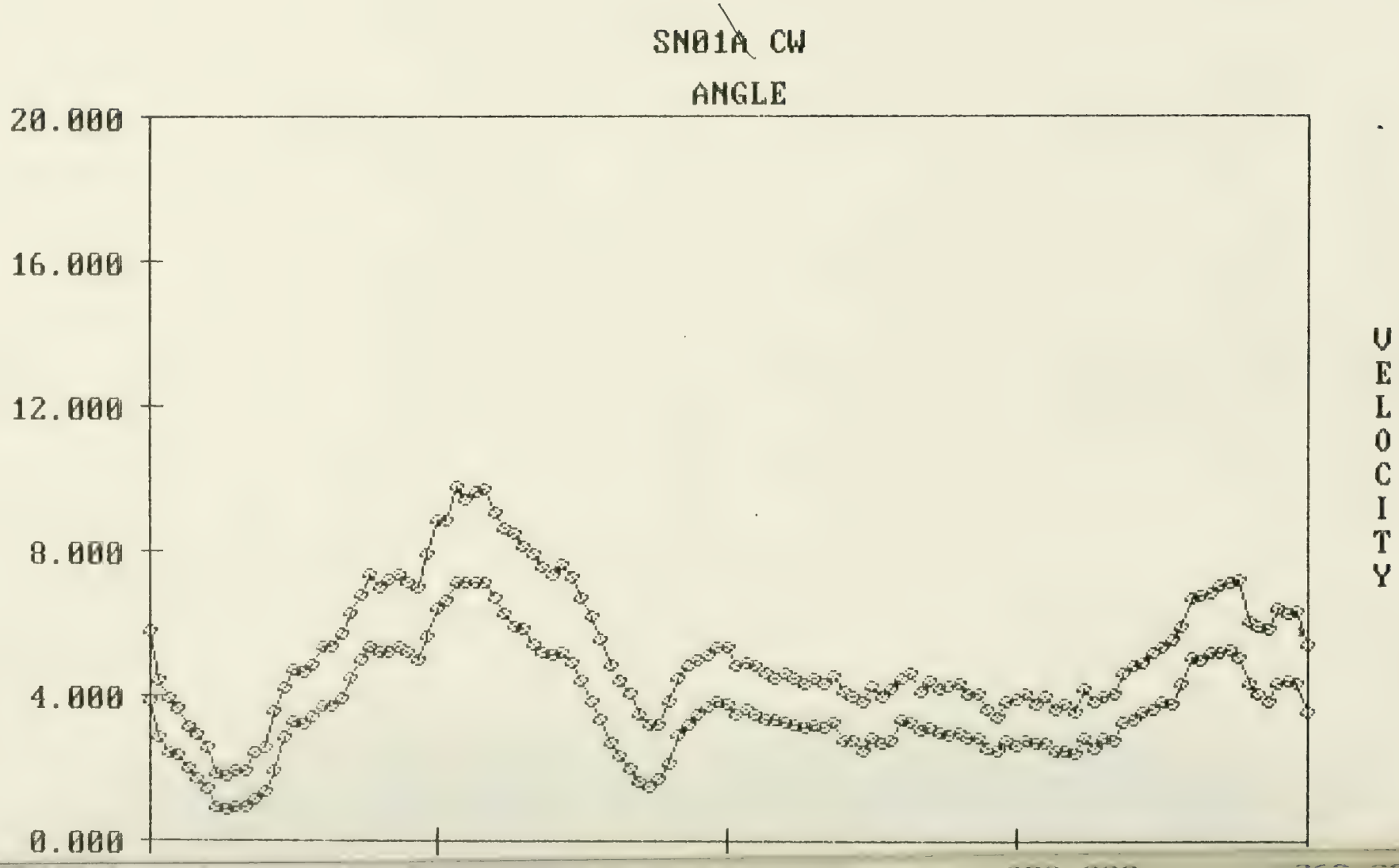
APPENDIX A

APPENDIX A

PEDESTRIAN LEVEL WIND IMPACTS

For each location two data sets are given: one with the present conditions (no build) and the other with the new building (build). Each data contains one figure and two tables. The figure presents the measured velocity (m/s) versus wind direction. The lower curve is the mean velocity, the upper curve is the gust velocity. The table that follows contains the probability that a given wind level will be exceeded. This table is based on all seasons and all directions and thus represents the annual wind condition. The final table is the velocity that is exceeded 1, 5, 10, 20 and 50% of the time. These tables are presented for each season and also for the annual winds. Both mean and gust data are presented. The top half of the table presents these data in metric (m/s) units. The bottom half of the table presents the same data in english (mph) units.

The data is organized by location given in Fig. 4.1.20 First we present the results for existing conditions, next for the build condition. On each page the data file is given a four letter name. The first letter is always S and stands for Summer Street. The second letter is either N, for no build, or B for build. The next two letters are used to indicate the location. Sometimes an additional letter is added. This letter indicates that the technician decided to run the test over to assure the data was correct.


SN01A CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

elocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.963095	0.984211
1.00	0.880604	0.942991
1.50	0.775557	0.882440
2.00	0.658762	0.808521
2.50	0.539724	0.726457
3.00	0.427503	0.640647
3.50	0.328622	0.554869
4.00	0.246356	0.472339
4.50	0.181096	0.395596
5.00	0.131266	0.326398
5.50	0.094313	0.265706
6.00	0.067479	0.213766
6.50	0.048262	0.170269
7.00	0.034613	0.134519
7.50	0.024958	0.105599
8.00	0.018135	0.082513
8.50	0.013308	0.064281
9.00	0.009883	0.050006
9.50	0.007445	0.038901
10.00	0.005699	0.030304
10.50	0.004439	0.023673
11.00	0.003522	0.018569
11.50	0.002845	0.014647
12.00	0.002337	0.011633
12.50	0.001948	0.009317
13.00	0.001644	0.007533
13.50	0.001400	0.006157
14.00	0.001200	0.005089
14.50	0.001033	0.004257
15.00	0.000891	0.003604
15.50	0.000769	0.003086
16.00	0.000664	0.002671
16.50	0.000572	0.002334
17.00	0.000492	0.002057
17.50	0.000422	0.001825
18.00	0.000361	0.001628
18.50	0.000308	0.001459
19.00	0.000262	0.001311
19.50	0.000223	0.001181
20.00	0.000188	0.001065
20.50	0.000159	0.000961
21.00	0.000133	0.000868
21.50	0.000112	0.000783
22.00	0.000094	0.000707
22.50	0.000078	0.000637
23.00	0.000065	0.000573
23.50	0.000054	0.000516
24.00	0.000044	0.000463
24.50	0.000036	0.000415
25.00	0.000030	0.000372

a

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.685	3.059	2.808	2.240	2.677
20%	4.396	4.787	4.600	3.586	4.355
10%	5.545	5.849	5.718	4.409	5.423
5%	6.806	6.833	6.749	5.172	6.455
1%	11.133	8.925	8.966	6.859	8.983

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.838	4.382	4.019	3.210	3.832
20%	6.212	6.769	6.491	5.082	6.158
10%	7.789	8.211	8.000	6.218	7.621
5%	9.451	9.505	9.384	7.246	9.000
1%	15.416	12.260	12.298	9.469	12.353

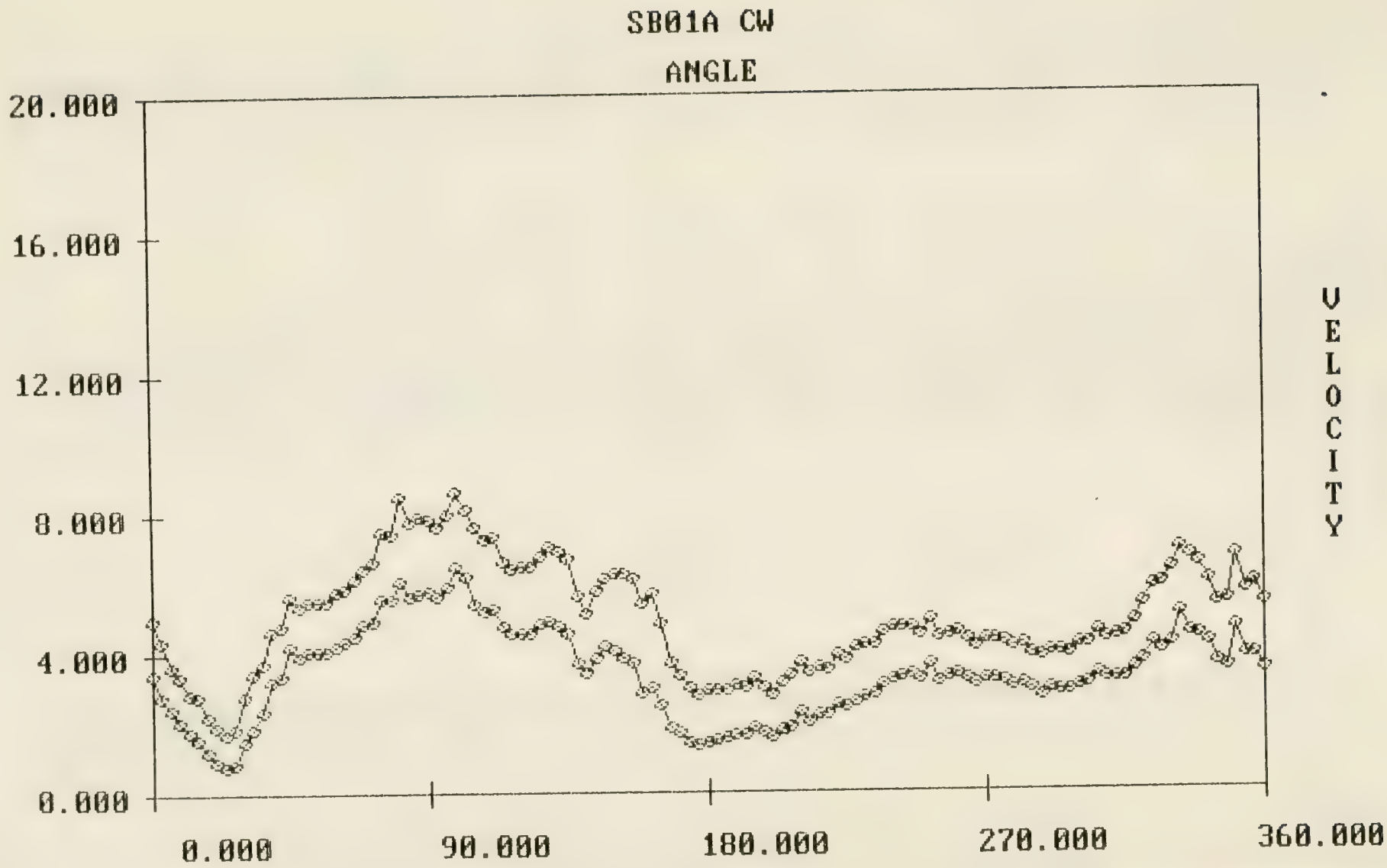
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.006	6.844	6.281	5.011	5.988
20%	9.833	10.708	10.291	8.022	9.742
10%	12.404	13.083	12.791	9.862	12.131
5%	15.224	15.285	15.098	11.570	14.439
1%	24.903	19.965	20.057	15.343	20.094

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.585	9.803	8.989	7.180	8.573
20%	13.896	15.141	14.520	11.369	13.776
10%	17.424	18.367	17.895	13.910	17.048
5%	21.141	21.263	20.991	16.210	20.133
1%	34.484	27.424	27.511	21.181	27.632

sn01a


SB01A CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.956931	0.982780
1.00	0.864983	0.938503
1.50	0.753556	0.874482
2.00	0.635361	0.797505
2.50	0.518693	0.713219
3.00	0.409966	0.626113
3.50	0.313787	0.539817
4.00	0.232838	0.457278
4.50	0.167857	0.380776
5.00	0.117943	0.311886
5.50	0.081109	0.251492
6.00	0.054873	0.199852
6.50	0.036743	0.156711
7.00	0.024519	0.121435
7.50	0.016428	0.093149
8.00	0.011135	0.070862
8.50	0.007691	0.053572
9.00	0.005446	0.040336
9.50	0.003967	0.030315
10.00	0.002977	0.022793
10.50	0.002297	0.017186
11.00	0.001815	0.013024
11.50	0.001461	0.009942
12.00	0.001192	0.007660
12.50	0.000981	0.005969
13.00	0.000812	0.004710
13.50	0.000673	0.003767
14.00	0.000558	0.003056
14.50	0.000461	0.002513
15.00	0.000381	0.002094
15.50	0.000313	0.001766
16.00	0.000257	0.001504
16.50	0.000210	0.001291
17.00	0.000170	0.001117
17.50	0.000138	0.000970
18.00	0.000111	0.000846
18.50	0.000089	0.000739
19.00	0.000071	0.000646
19.50	0.000056	0.000565
20.00	0.000045	0.000495
20.50	0.000035	0.000432
21.00	0.000028	0.000377
21.50	0.000022	0.000329
22.00	0.000017	0.000286
22.50	0.000013	0.000248
23.00	0.000010	0.000215
23.50	0.000008	0.000186
24.00	0.000006	0.000161
24.50	0.000004	0.000138
25.00	0.000003	0.000119

sb01a

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.571	3.014	2.675	2.150	2.586
20%	4.268	4.665	4.453	3.534	4.253
10%	5.330	5.592	5.491	4.353	5.244
5%	6.382	6.406	6.414	5.043	6.134
1%	9.665	8.067	8.268	6.475	8.165

Vgust (m/s)

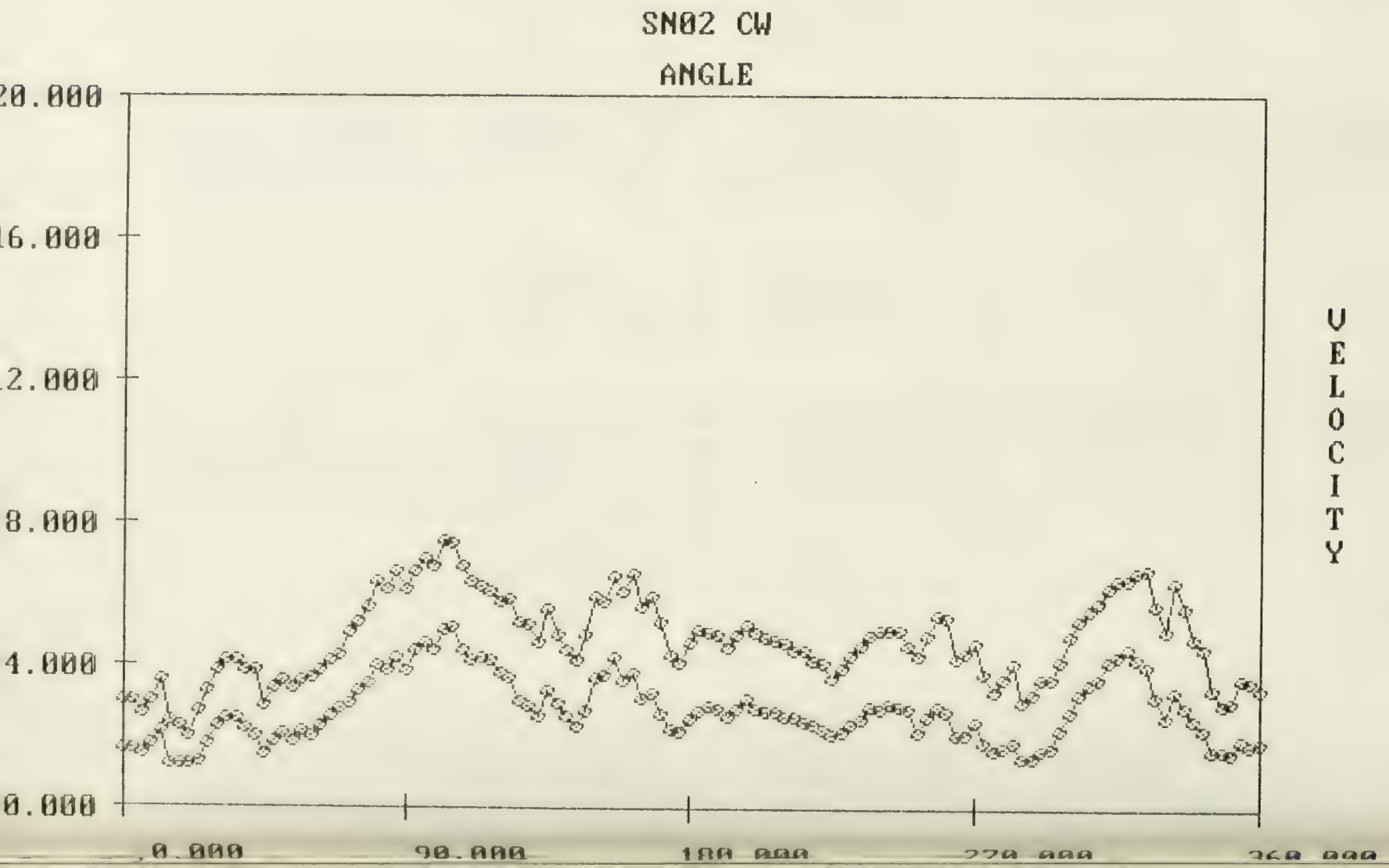
bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.728	4.313	3.884	3.131	3.741
20%	6.035	6.575	6.298	5.015	5.999
10%	7.508	7.886	7.734	6.134	7.379
5%	8.990	9.036	8.987	7.112	8.635
1%	13.527	11.458	11.571	9.135	11.491

Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.751	6.743	5.985	4.810	5.785
20%	9.547	10.436	9.961	7.906	9.513
10%	11.922	12.510	12.283	9.737	11.730
5%	14.277	14.331	14.347	11.280	13.722
1%	21.620	18.046	18.494	14.485	18.264

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.340	9.648	8.688	7.003	8.369
20%	13.499	14.708	14.087	11.219	13.418
10%	16.795	17.640	17.300	13.722	16.506
5%	20.109	20.213	20.104	15.908	19.316
1%	30.259	25.630	25.883	20.434	25.704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ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

city (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.949648	0.984092
1.00	0.822156	0.940667
1.50	0.660313	0.875249
2.00	0.502192	0.794741
2.50	0.368309	0.706183
3.00	0.263882	0.615704
3.50	0.186080	0.527999
4.00	0.129634	0.446256
4.50	0.089420	0.372343
5.00	0.061184	0.307100
5.50	0.041599	0.250636
6.00	0.028152	0.202580
6.50	0.018994	0.162272
7.00	0.012800	0.128897
7.50	0.008636	0.101587
8.00	0.005851	0.079479
8.50	0.003996	0.061759
9.00	0.002762	0.047688
9.50	0.001940	0.036612
10.00	0.001390	0.027964
10.50	0.001017	0.021264
11.00	0.000759	0.016113
11.50	0.000576	0.012179
12.00	0.000444	0.009194
12.50	0.000345	0.006943
13.00	0.000270	0.005253
13.50	0.000212	0.003991
14.00	0.000166	0.003049
14.50	0.000129	0.002348
15.00	0.000101	0.001825
15.50	0.000078	0.001435
16.00	0.000060	0.001141
16.50	0.000046	0.000917
17.00	0.000035	0.000746
17.50	0.000026	0.000613
18.00	0.000020	0.000508
18.50	0.000015	0.000424
19.00	0.000011	0.000356
19.50	0.000008	0.000300
20.00	0.000006	0.000254
20.50	0.000004	0.000215
21.00	0.000003	0.000182
21.50	0.000002	0.000154
22.00	0.000002	0.000130
22.50	0.000001	0.000110
23.00	0.000001	0.000092
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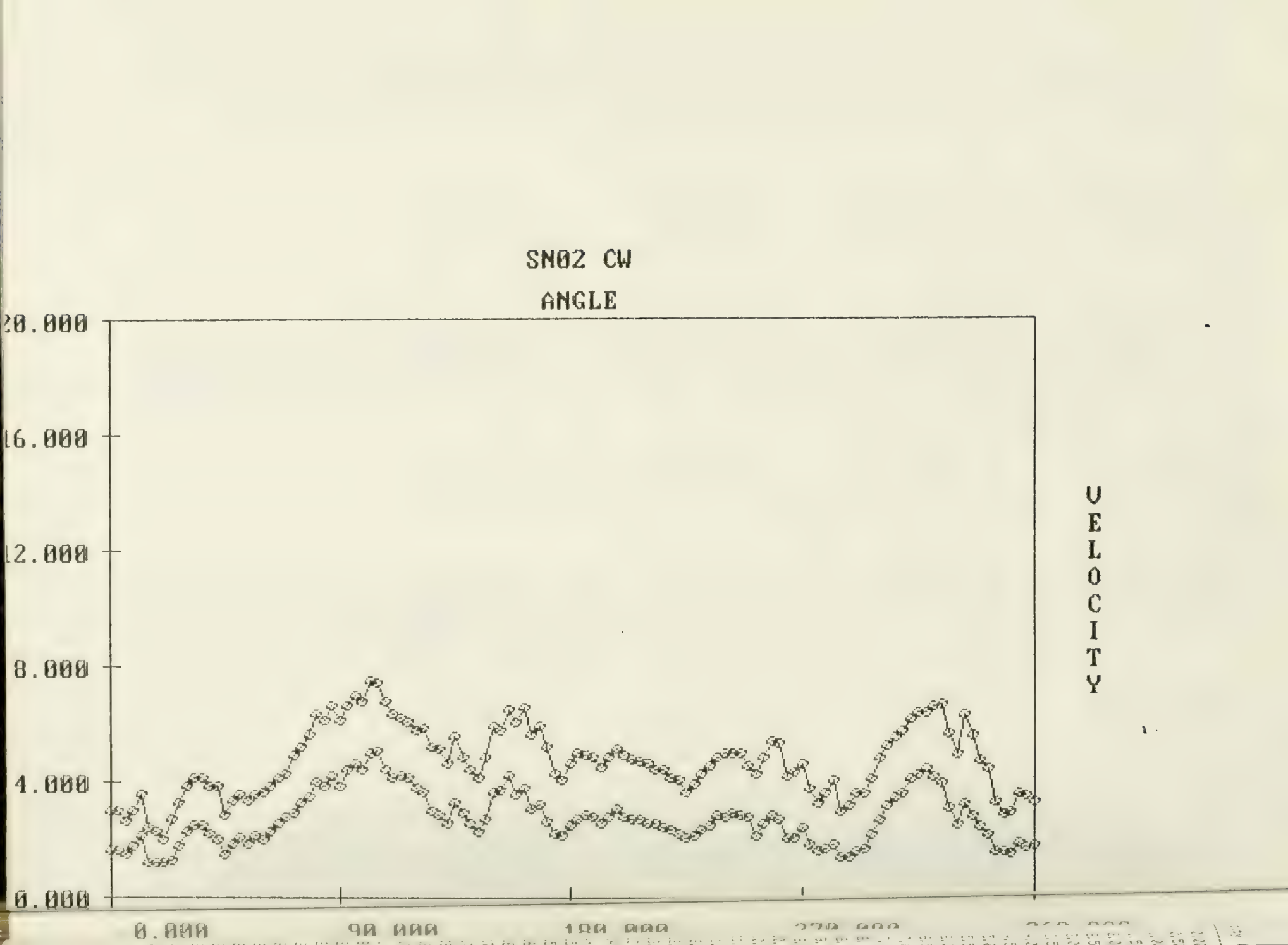

SN02 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.949648	0.984092
1.00	0.822156	0.940667
1.50	0.660313	0.875249
2.00	0.502192	0.794741
2.50	0.368309	0.706183
3.00	0.263882	0.615704
3.50	0.186080	0.527999
4.00	0.129634	0.446256
4.50	0.089420	0.372343
5.00	0.061184	0.307100
5.50	0.041599	0.250636
6.00	0.028152	0.202580
6.50	0.018994	0.162272
7.00	0.012800	0.128897
7.50	0.008636	0.101587
8.00	0.005851	0.079479
8.50	0.003996	0.061759
9.00	0.002762	0.047688
9.50	0.001940	0.036612
10.00	0.001390	0.027964
10.50	0.001017	0.021264
11.00	0.000759	0.016113
11.50	0.000576	0.012179
12.00	0.000444	0.009194
12.50	0.000345	0.006943
13.00	0.000270	0.005253
13.50	0.000212	0.003991
14.00	0.000166	0.003049
14.50	0.000129	0.002348
15.00	0.000101	0.001825
15.50	0.000078	0.001435
16.00	0.000060	0.001141
16.50	0.000046	0.000917
17.00	0.000035	0.000746
17.50	0.000026	0.000613
18.00	0.000020	0.000508
18.50	0.000015	0.000424
19.00	0.000011	0.000356
19.50	0.000008	0.000300
20.00	0.000006	0.000254
20.50	0.000004	0.000215
21.00	0.000003	0.000182
21.50	0.000002	0.000154
22.00	0.000002	0.000130
22.50	0.000001	0.000110
23.00	0.000001	0.000092
23.50	0.000001	0.000078
24.00	0.000000	0.000065
24.50	0.000000	0.000055
25.00	0.000000	0.000046

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.013	2.282	2.096	1.720	2.008
20%	3.445	3.817	3.547	2.848	3.411
10%	4.428	4.852	4.512	3.562	4.368
5%	5.398	5.799	5.432	4.246	5.286
1%	7.969	7.709	7.382	5.660	7.336

Vgust (m/s)

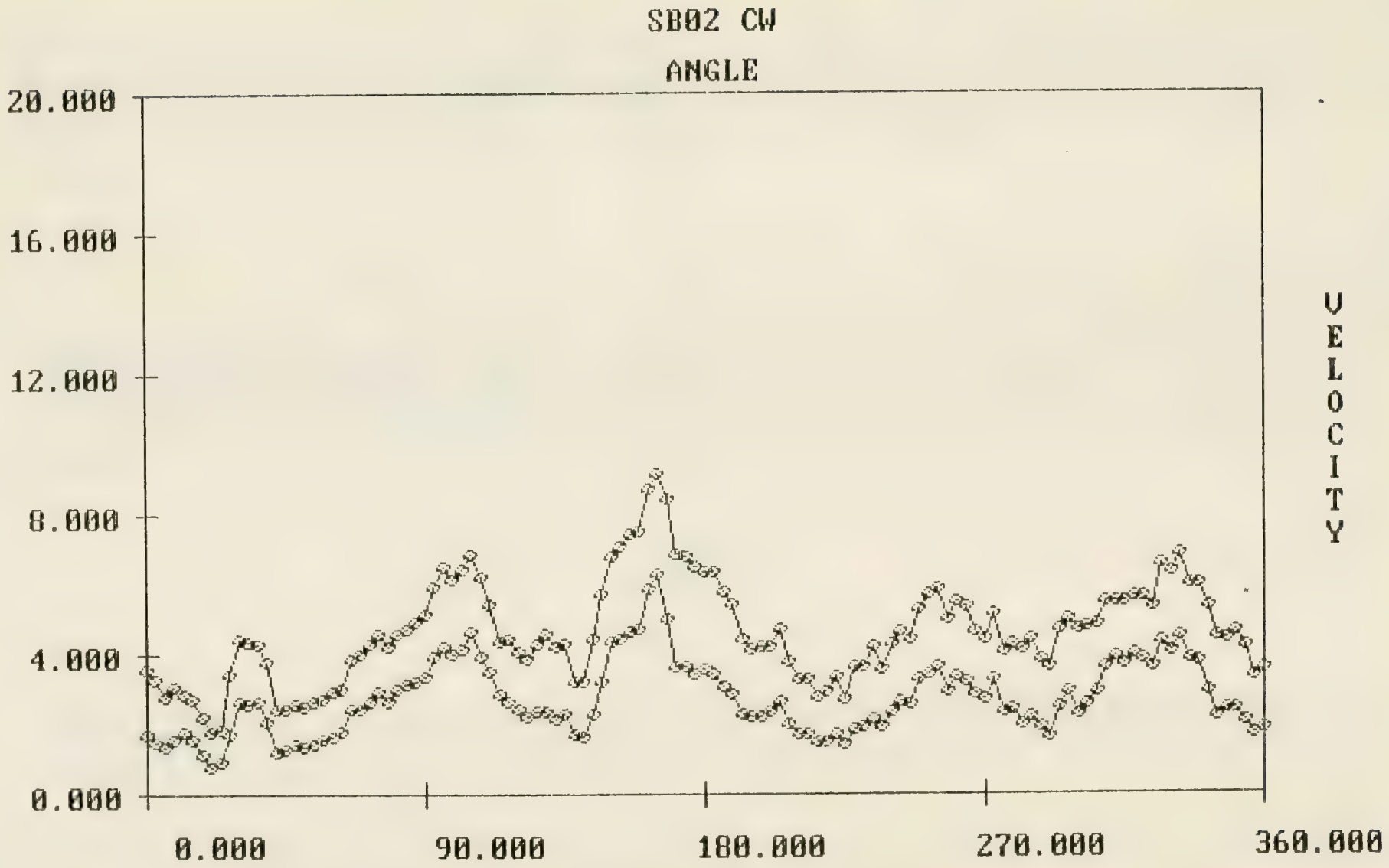
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.668	4.211	3.795	3.117	3.671
20%	6.060	6.746	6.268	5.039	6.032
10%	7.602	8.306	7.812	6.233	7.536
5%	9.047	9.684	9.198	7.289	8.918
1%	12.648	12.396	12.005	9.424	11.865

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.503	5.104	4.689	3.849	4.492
20%	7.706	8.539	7.935	6.371	7.629
10%	9.905	10.853	10.094	7.967	9.772
5%	12.075	12.972	12.151	9.499	11.823
1%	17.826	17.246	16.514	12.662	16.411

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.204	9.419	8.488	6.973	8.212
20%	13.557	15.091	14.022	11.273	13.493
10%	17.005	18.580	17.475	13.942	16.857
5%	20.238	21.663	20.575	16.304	19.949
1%	28.293	27.729	26.854	21.080	26.541


SB02 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.947253	0.982911
1.00	0.822413	0.936897
1.50	0.672286	0.869295
2.00	0.527291	0.788386
2.50	0.401177	0.701508
3.00	0.298020	0.614128
3.50	0.217111	0.529892
4.00	0.155550	0.451092
4.50	0.109751	0.379108
5.00	0.076278	0.314685
5.50	0.052199	0.258096
6.00	0.035149	0.209245
6.50	0.023279	0.167756
7.00	0.015164	0.133059
7.50	0.009721	0.104459
8.00	0.006143	0.081207
8.50	0.003836	0.062545
9.00	0.002375	0.047750
9.50	0.001465	0.036156
10.00	0.000905	0.027168
10.50	0.000563	0.020273
11.00	0.000355	0.015033
11.50	0.000227	0.011087
12.00	0.000148	0.008140
12.50	0.000098	0.005955
13.00	0.000066	0.004345
13.50	0.000045	0.003167
14.00	0.000031	0.002307
14.50	0.000021	0.001682
15.00	0.000015	0.001229
15.50	0.000010	0.000901
16.00	0.000007	0.000663
16.50	0.000005	0.000490
17.00	0.000003	0.000364
17.50	0.000002	0.000272
18.00	0.000001	0.000204
18.50	0.000001	0.000155
19.00	0.000001	0.000117
19.50	0.000000	0.000090
20.00	0.000000	0.000069
20.50	0.000000	0.000053
21.00	0.000000	0.000041
21.50	0.000000	0.000031
22.00	0.000000	0.000024
22.50	0.000000	0.000019
23.00	0.000000	0.000015
23.50	0.000000	0.000011
24.00	0.000000	0.000009
24.50	0.000000	0.000007
25.00	0.000000	0.000005

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.087	2.497	2.174	1.757	2.108
20%	3.597	4.139	3.798	2.967	3.639
10%	4.607	5.161	4.859	3.779	4.646
5%	5.546	6.064	5.826	4.488	5.564
1%	7.594	7.885	7.763	6.004	7.474

Vgust (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.656	4.368	3.790	3.080	3.690
20%	6.036	6.906	6.343	5.052	6.111
10%	7.508	8.376	7.909	6.264	7.596
5%	8.876	9.655	9.299	7.335	8.924
1%	11.903	12.223	12.069	9.510	11.684

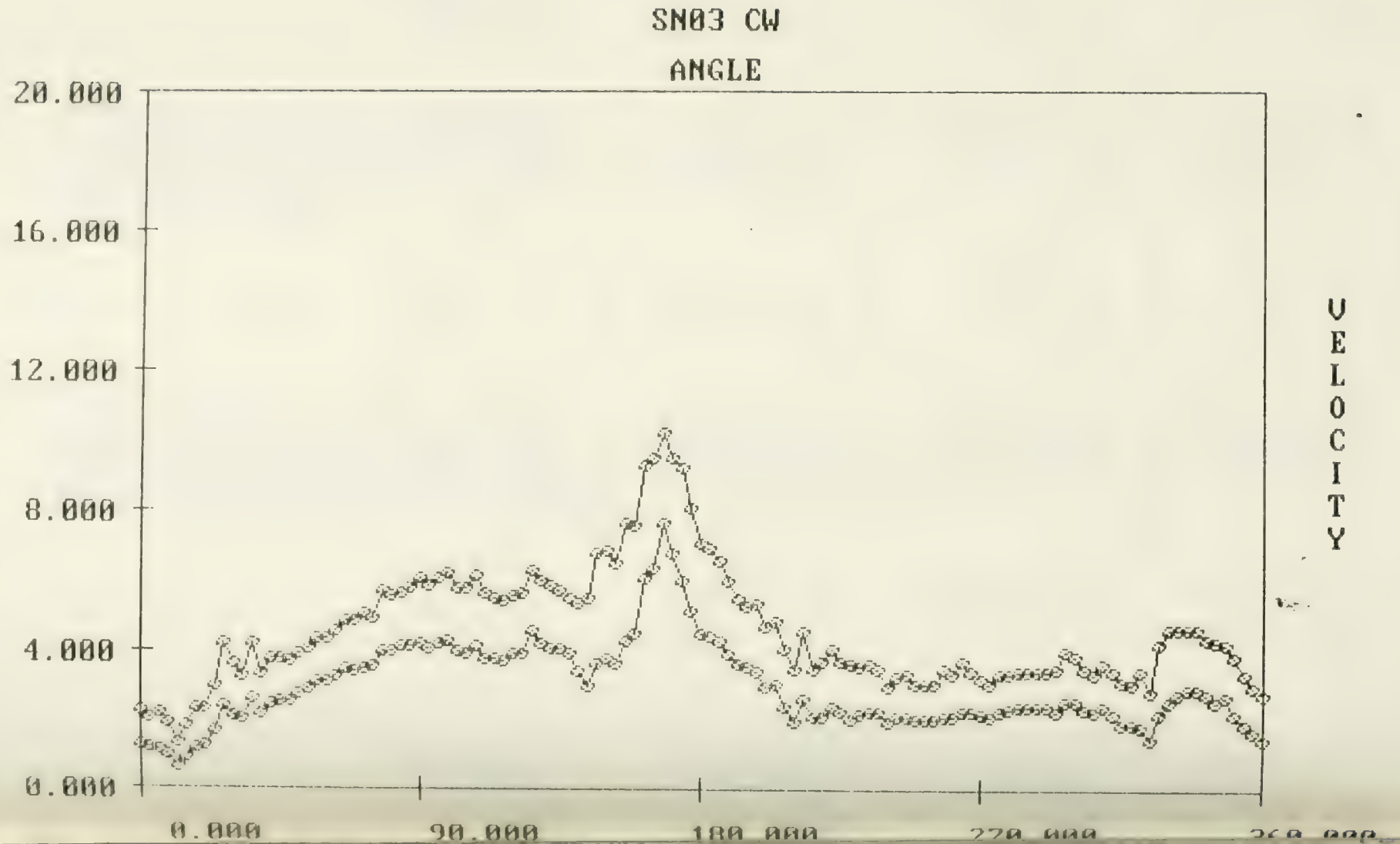
Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.668	5.587	4.864	3.930	4.716
20%	8.046	9.260	8.496	6.637	8.140
10%	10.305	11.545	10.870	8.453	10.392
5%	12.407	13.564	13.032	10.040	12.447
1%	16.987	17.639	17.366	13.431	16.720

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.178	9.770	8.478	6.890	8.254
20%	13.501	15.449	14.189	11.300	13.671
10%	16.796	18.737	17.691	14.013	16.992
5%	19.854	21.598	20.802	16.409	19.962
1%	26.626	27.342	26.999	21.274	26.137

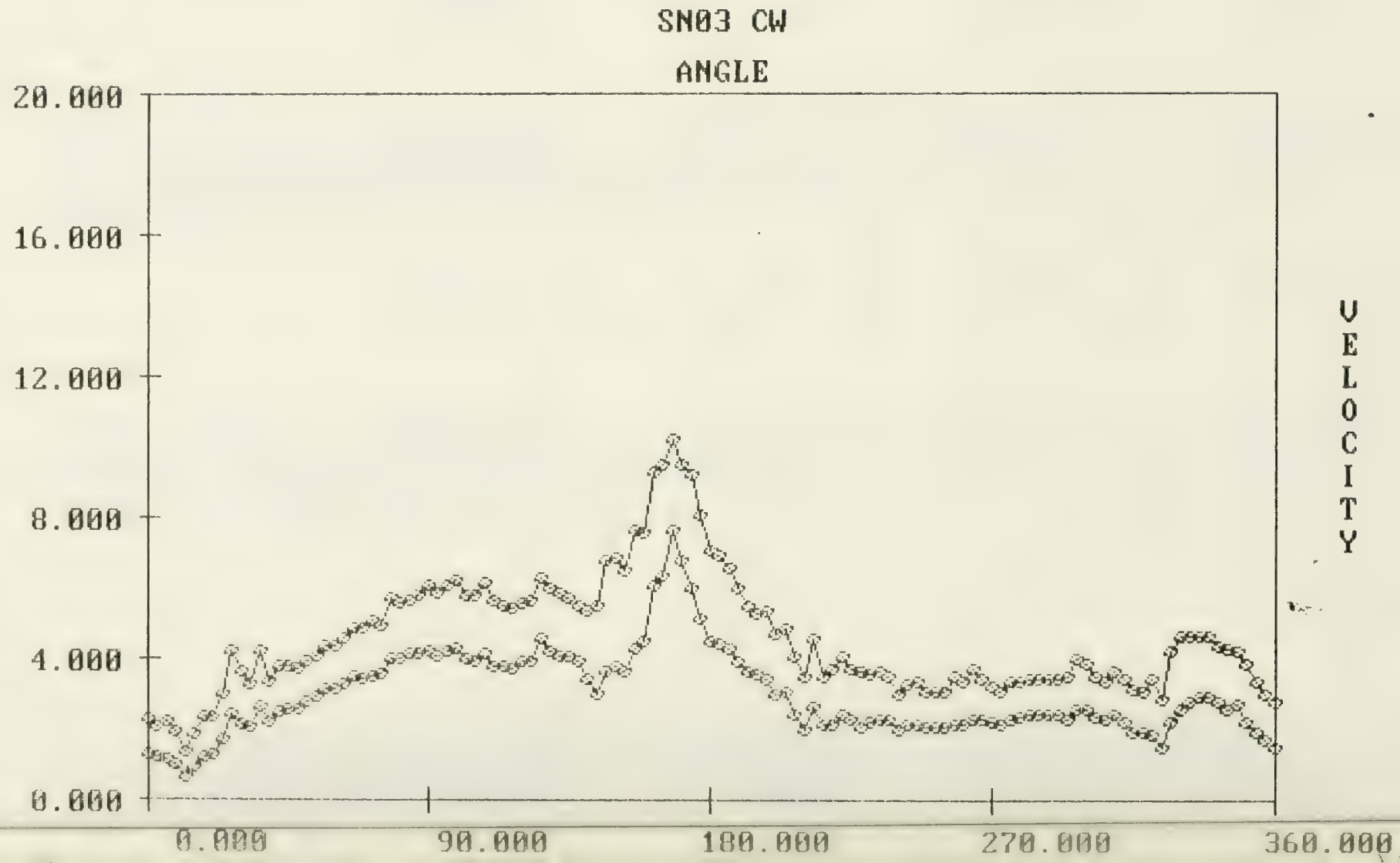
02


SN03 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
0.000
90.000
180.000
270.000
VELOCITY

BOSTON ANNUAL

ocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.949409	0.980193
1.00	0.826521	0.925148
1.50	0.669209	0.843045
2.00	0.505972	0.743558
2.50	0.358378	0.635819
3.00	0.239365	0.527755
3.50	0.152364	0.425758
4.00	0.093788	0.334395
4.50	0.056894	0.256299
5.00	0.034785	0.192298
5.50	0.021920	0.141783
6.00	0.014469	0.103202
6.50	0.010050	0.074545
7.00	0.007302	0.053735
7.50	0.005484	0.038876
8.00	0.004210	0.028382
8.50	0.003274	0.021004
9.00	0.002565	0.015807
9.50	0.002017	0.012115
10.00	0.001588	0.009456
10.50	0.001250	0.007505
11.00	0.000983	0.006044
11.50	0.000772	0.004925
12.00	0.000605	0.004050
12.50	0.000473	0.003354
13.00	0.000369	0.002791
13.50	0.000287	0.002330
14.00	0.000223	0.001950
14.50	0.000172	0.001633
15.00	0.000133	0.001369
15.50	0.000102	0.001148
16.00	0.000078	0.000962
16.50	0.000060	0.000806
17.00	0.000046	0.000674
17.50	0.000035	0.000564
18.00	0.000026	0.000471
18.50	0.000020	0.000393
19.00	0.000015	0.000327
19.50	0.000011	0.000272
20.00	0.000008	0.000226
20.50	0.000006	0.000188
21.00	0.000005	0.000156
21.50	0.000003	0.000129
22.00	0.000002	0.000106
22.50	0.000002	0.000088
23.00	0.000001	0.000072
23.50	0.000001	0.000059
24.00	0.000001	0.000049
24.50	0.000001	0.000040
25.00	0.000000	0.000033

\sn03


SN03 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
0.000
90.000
180.000
270.000
360.000
VELOCITY

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.949409	0.980193
1.00	0.826521	0.925148
1.50	0.669209	0.843045
2.00	0.505972	0.743558
2.50	0.358378	0.635819
3.00	0.239365	0.527755
3.50	0.152364	0.425758
4.00	0.093788	0.334395
4.50	0.056894	0.256299
5.00	0.034785	0.192298
5.50	0.021920	0.141783
6.00	0.014469	0.103202
6.50	0.010050	0.074545
7.00	0.007302	0.053735
7.50	0.005484	0.038876
8.00	0.004210	0.028382
8.50	0.003274	0.021004
9.00	0.002565	0.015807
9.50	0.002017	0.012115
10.00	0.001588	0.009456
10.50	0.001250	0.007505
11.00	0.000983	0.006044
11.50	0.000772	0.004925
12.00	0.000605	0.004050
12.50	0.000473	0.003354
13.00	0.000369	0.002791
13.50	0.000287	0.002330
14.00	0.000223	0.001950
14.50	0.000172	0.001633
15.00	0.000133	0.001369
15.50	0.000102	0.001148
16.00	0.000078	0.000962
16.50	0.000060	0.000806
17.00	0.000046	0.000674
17.50	0.000035	0.000564
18.00	0.000026	0.000471
18.50	0.000020	0.000393
19.00	0.000015	0.000327
19.50	0.000011	0.000272
20.00	0.000008	0.000226
20.50	0.000006	0.000188
21.00	0.000005	0.000156
21.50	0.000003	0.000129
22.00	0.000002	0.000106
22.50	0.000002	0.000088
23.00	0.000001	0.000072
23.50	0.000001	0.000059
24.00	0.000001	0.000049
24.50	0.000001	0.000040
25.00	0.000000	0.000033

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.021	2.267	2.117	1.738	2.020
20%	3.250	3.467	3.390	2.749	3.226
10%	4.015	4.194	4.164	3.343	3.947
5%	4.871	4.843	4.867	3.880	4.656
1%	7.899	6.468	6.473	5.128	6.509

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.139	3.505	3.288	2.683	3.136
20%	4.977	5.341	5.207	4.201	4.940
10%	6.194	6.426	6.359	5.100	6.056
5%	7.445	7.437	7.408	5.926	7.126
1%	11.591	10.000	9.826	7.850	9.898

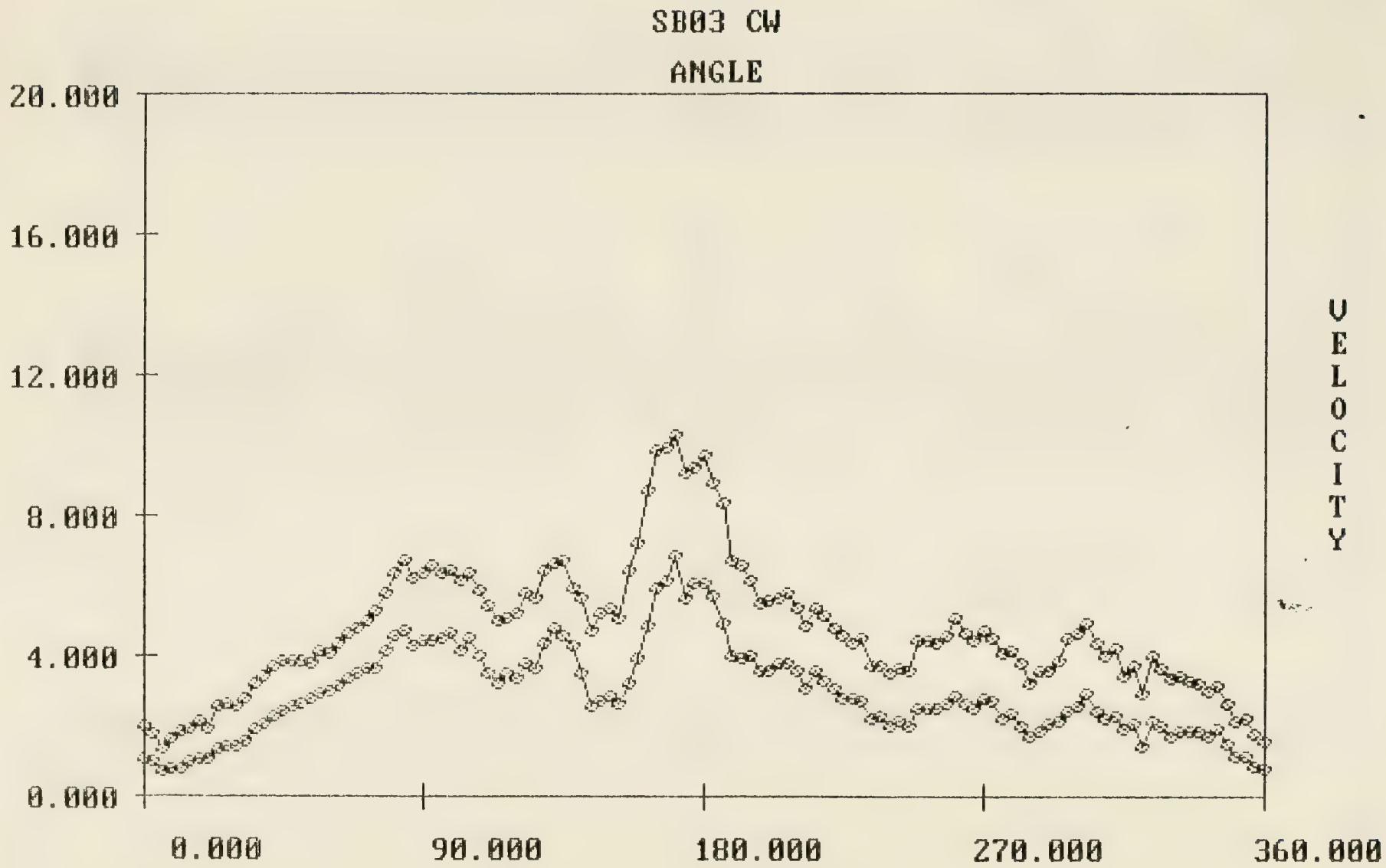
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.521	5.070	4.736	3.888	4.519
20%	7.271	7.756	7.583	6.149	7.217
10%	8.981	9.381	9.314	7.478	8.829
5%	10.896	10.834	10.888	8.679	10.415
1%	17.671	14.468	14.480	11.472	14.561

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.022	7.841	7.355	6.003	7.015
20%	11.134	11.948	11.647	9.397	11.050
10%	13.855	14.374	14.225	11.408	13.547
5%	16.653	16.637	16.572	13.256	15.940
1%	25.927	22.370	21.979	17.560	22.140

\nb17\sm03


SB03 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.939814	0.979605
1.00	0.805658	0.925058
1.50	0.649693	0.847511
2.00	0.495761	0.757719
2.50	0.359358	0.663294
3.00	0.249616	0.569268
3.50	0.168058	0.479289
4.00	0.110976	0.396157
4.50	0.072680	0.321834
5.00	0.047673	0.257381
5.50	0.031574	0.203002
6.00	0.021243	0.158222
6.50	0.014571	0.122121
7.00	0.010202	0.093542
7.50	0.007284	0.071268
8.00	0.005292	0.054131
8.50	0.003899	0.041085
9.00	0.002904	0.031232
9.50	0.002180	0.023831
10.00	0.001645	0.018287
10.50	0.001245	0.014135
11.00	0.000944	0.011018
11.50	0.000716	0.008665
12.00	0.000542	0.006876
12.50	0.000410	0.005504
13.00	0.000310	0.004440
13.50	0.000234	0.003606
14.00	0.000176	0.002945
14.50	0.000132	0.002416
15.00	0.000099	0.001989
15.50	0.000073	0.001642
16.00	0.000055	0.001357
16.50	0.000041	0.001123
17.00	0.000030	0.000930
17.50	0.000022	0.000770
18.00	0.000016	0.000637
18.50	0.000012	0.000527
19.00	0.000009	0.000436
19.50	0.000006	0.000360
20.00	0.000005	0.000297
20.50	0.000003	0.000244
21.00	0.000002	0.000201
21.50	0.000002	0.000165
22.00	0.000001	0.000135
22.50	0.000001	0.000111
23.00	0.000001	0.000091
23.50	0.000000	0.000074
24.00	0.000000	0.000060
24.50	0.000000	0.000049
25.00	0.000000	0.000040

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.993	2.181	2.054	1.760	1.986
20%	3.365	3.476	3.445	2.890	3.304
10%	4.308	4.314	4.337	3.581	4.143
5%	5.296	5.094	5.159	4.242	4.953
1%	8.078	7.153	6.991	5.687	7.035

Vgust (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.388	3.773	3.482	2.959	3.385
20%	5.589	5.978	5.763	4.800	5.534
10%	7.020	7.328	7.166	5.906	6.887
5%	8.461	8.560	8.447	6.912	8.158
1%	12.362	11.548	11.310	9.101	11.216

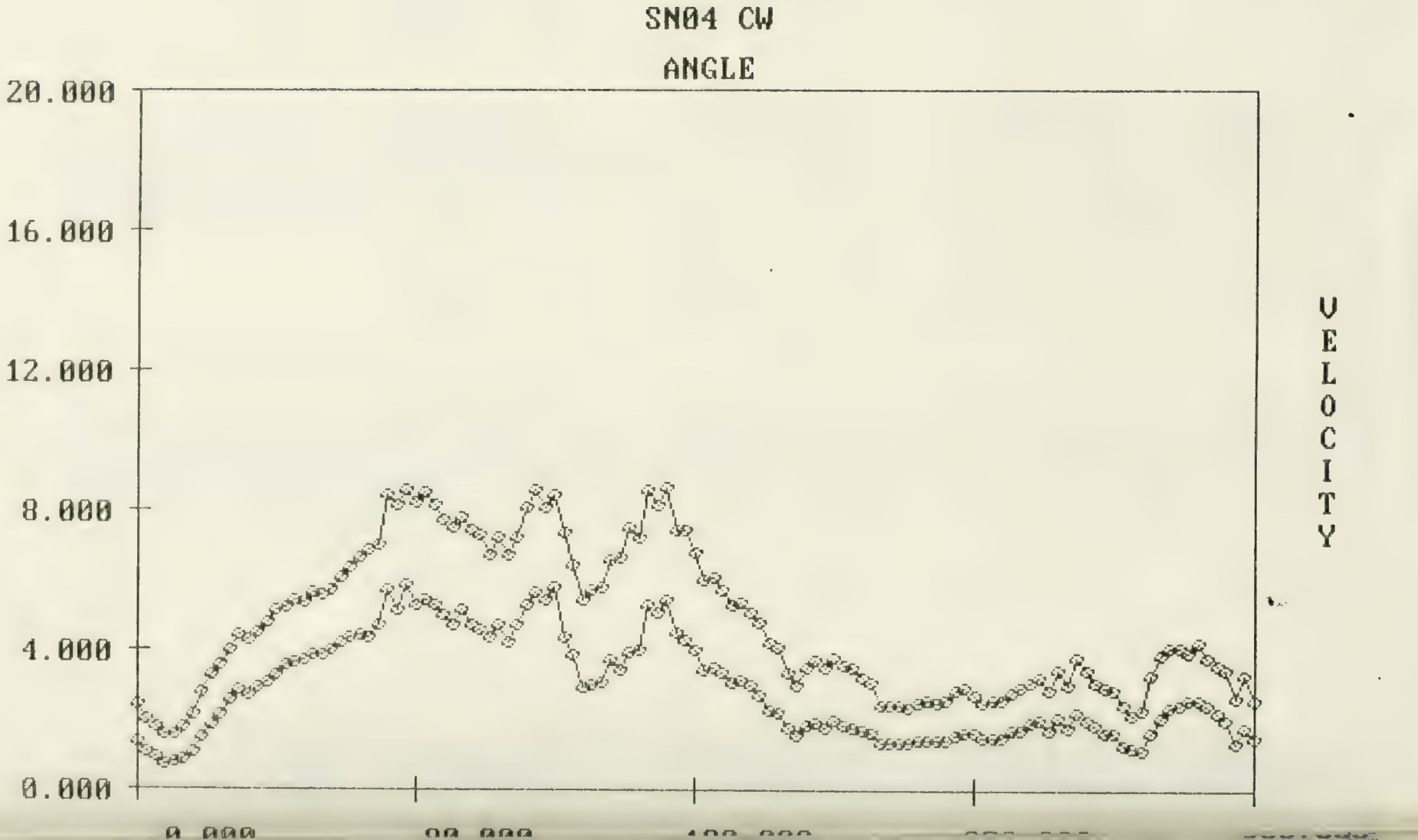
Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.459	4.878	4.595	3.937	4.443
20%	7.528	7.776	7.706	6.464	7.391
10%	9.636	9.650	9.703	8.011	9.268
5%	11.848	11.396	11.541	9.490	11.081
1%	18.071	16.001	15.638	12.722	15.736

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.578	8.440	7.789	6.618	7.572
20%	12.501	13.373	12.892	10.738	12.378
10%	15.703	16.393	16.031	13.211	15.406
5%	18.927	19.149	18.895	15.461	18.250
1%	27.653	25.833	25.300	20.358	25.090

b17\sb03


SN04 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.928173	0.976329
1.00	0.755178	0.909584
1.50	0.552691	0.810828
2.00	0.372149	0.694378
2.50	0.237059	0.573576
3.00	0.147184	0.458855
3.50	0.091454	0.357136
4.00	0.057995	0.271868
4.50	0.037949	0.203592
5.00	0.025705	0.150879
5.50	0.017994	0.111299
6.00	0.012972	0.082168
6.50	0.009597	0.061003
7.00	0.007267	0.045721
7.50	0.005620	0.034693
8.00	0.004430	0.026697
8.50	0.003552	0.020848
9.00	0.002889	0.016518
9.50	0.002377	0.013270
10.00	0.001973	0.010798
10.50	0.001649	0.008889
11.00	0.001384	0.007397
11.50	0.001164	0.006215
12.00	0.000981	0.005268
12.50	0.000826	0.004503
13.00	0.000695	0.003877
13.50	0.000584	0.003360
14.00	0.000489	0.002929
14.50	0.000409	0.002567
15.00	0.000341	0.002259
15.50	0.000284	0.001996
16.00	0.000236	0.001768
16.50	0.000195	0.001570
17.00	0.000161	0.001397
17.50	0.000132	0.001245
18.00	0.000108	0.001110
18.50	0.000088	0.000990
19.00	0.000072	0.000883
19.50	0.000059	0.000787
20.00	0.000047	0.000702
20.50	0.000038	0.000626
21.00	0.000031	0.000557
21.50	0.000025	0.000496
22.00	0.000020	0.000440
22.50	0.000016	0.000391
23.00	0.000013	0.000347
23.50	0.000010	0.000307
24.00	0.000008	0.000272
24.50	0.000006	0.000240
25.00	0.000005	0.000212

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.651	1.812	1.754	1.397	1.646
20%	2.752	2.844	2.900	2.293	2.706
10%	3.578	3.477	3.691	2.886	3.423
5%	4.665	4.129	4.471	3.477	4.199
1%	8.962	5.774	6.420	4.960	6.440

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.829	3.099	2.993	2.409	2.821
20%	4.620	4.784	4.858	3.866	4.534
10%	5.932	5.841	6.064	4.818	5.694
5%	7.508	6.864	7.262	5.739	6.860
1%	13.884	9.458	10.085	7.880	10.209

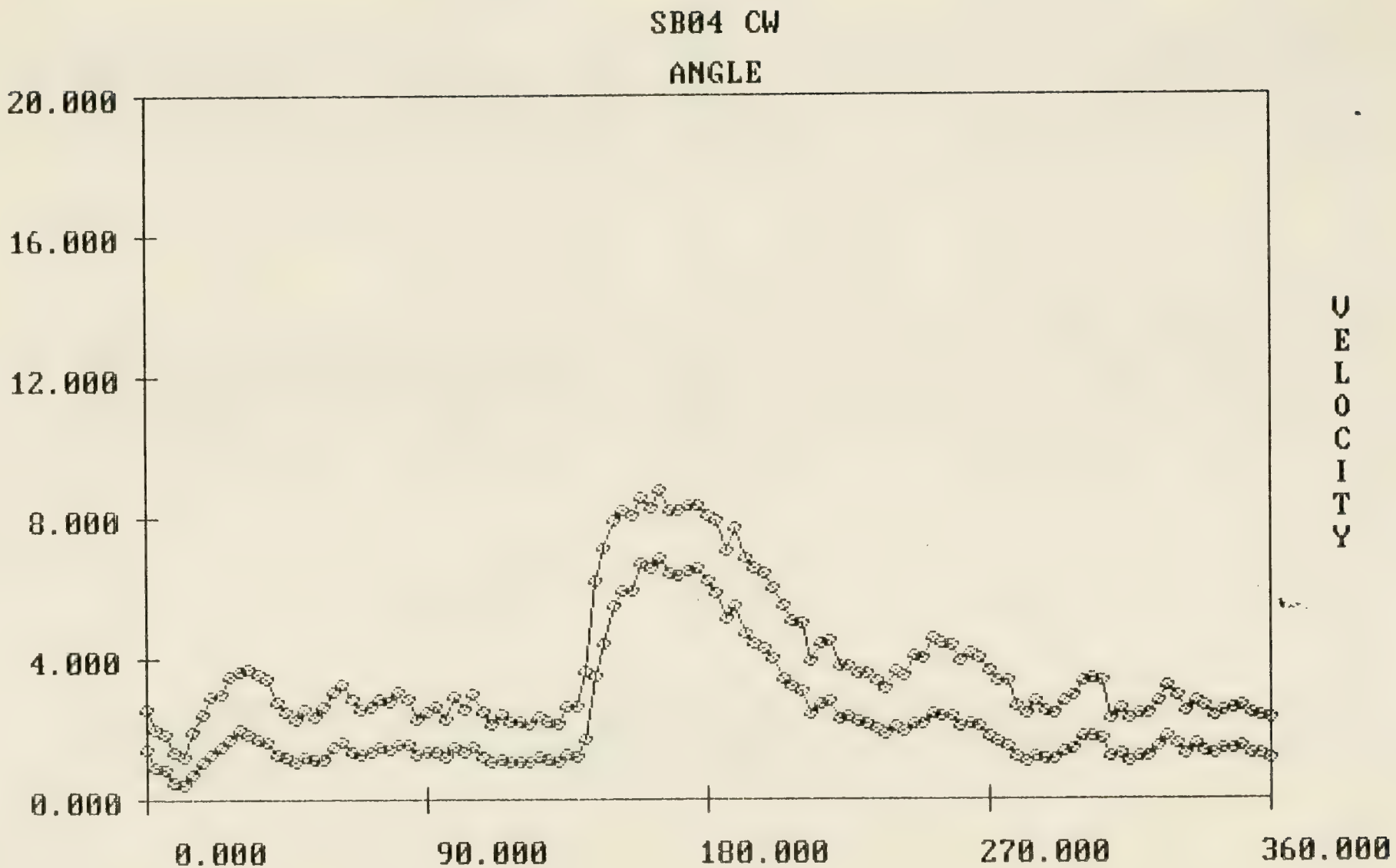
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.692	4.054	3.923	3.125	3.682
20%	6.157	6.363	6.488	5.129	6.054
10%	8.004	7.777	8.257	6.456	7.658
5%	10.435	9.236	10.001	7.778	9.394
1%	20.046	12.917	14.361	11.095	14.407

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.329	6.931	6.696	5.388	6.310
20%	10.335	10.702	10.866	8.649	10.142
10%	13.269	13.067	13.566	10.777	12.737
5%	16.795	15.355	16.245	12.839	15.345
1%	31.059	21.157	22.559	17.627	22.837

\nb17\sn04


SB04 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.895767	0.970815
1.00	0.679226	0.892203
1.50	0.462925	0.781843
2.00	0.300410	0.658369
2.50	0.193602	0.536550
3.00	0.126250	0.426105
3.50	0.083753	0.331904
4.00	0.056713	0.255026
4.50	0.039310	0.194202
5.00	0.027888	0.147070
5.50	0.020184	0.111028
6.00	0.014828	0.083688
6.50	0.010999	0.063051
7.00	0.008199	0.047522
7.50	0.006122	0.035860
8.00	0.004568	0.027110
8.50	0.003400	0.020544
9.00	0.002523	0.015612
9.50	0.001865	0.011899
10.00	0.001373	0.009096
10.50	0.001007	0.006973
11.00	0.000736	0.005360
11.50	0.000535	0.004129
12.00	0.000388	0.003186
12.50	0.000280	0.002462
13.00	0.000201	0.001905
13.50	0.000144	0.001474
14.00	0.000103	0.001141
14.50	0.000073	0.000883
15.00	0.000052	0.000682
15.50	0.000037	0.000527
16.00	0.000026	0.000407
16.50	0.000018	0.000313
17.00	0.000013	0.000241
17.50	0.000009	0.000185
18.00	0.000006	0.000142
18.50	0.000004	0.000109
19.00	0.000003	0.000083
19.50	0.000002	0.000064
20.00	0.000001	0.000049
20.50	0.000001	0.000037
21.00	0.000001	0.000028
21.50	0.000000	0.000021
22.00	0.000000	0.000016
22.50	0.000000	0.000012
23.00	0.000000	0.000009
23.50	0.000000	0.000007
24.00	0.000000	0.000005
24.50	0.000000	0.000004
25.00	0.000000	0.000003

\nb17\sb04

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.416	1.534	1.431	1.282	1.414
20%	2.489	2.578	2.535	2.293	2.470
10%	3.356	3.411	3.432	2.994	3.309
5%	4.249	4.370	4.403	3.753	4.193
1%	6.604	7.339	6.995	5.650	6.678

Vgust (m/s)

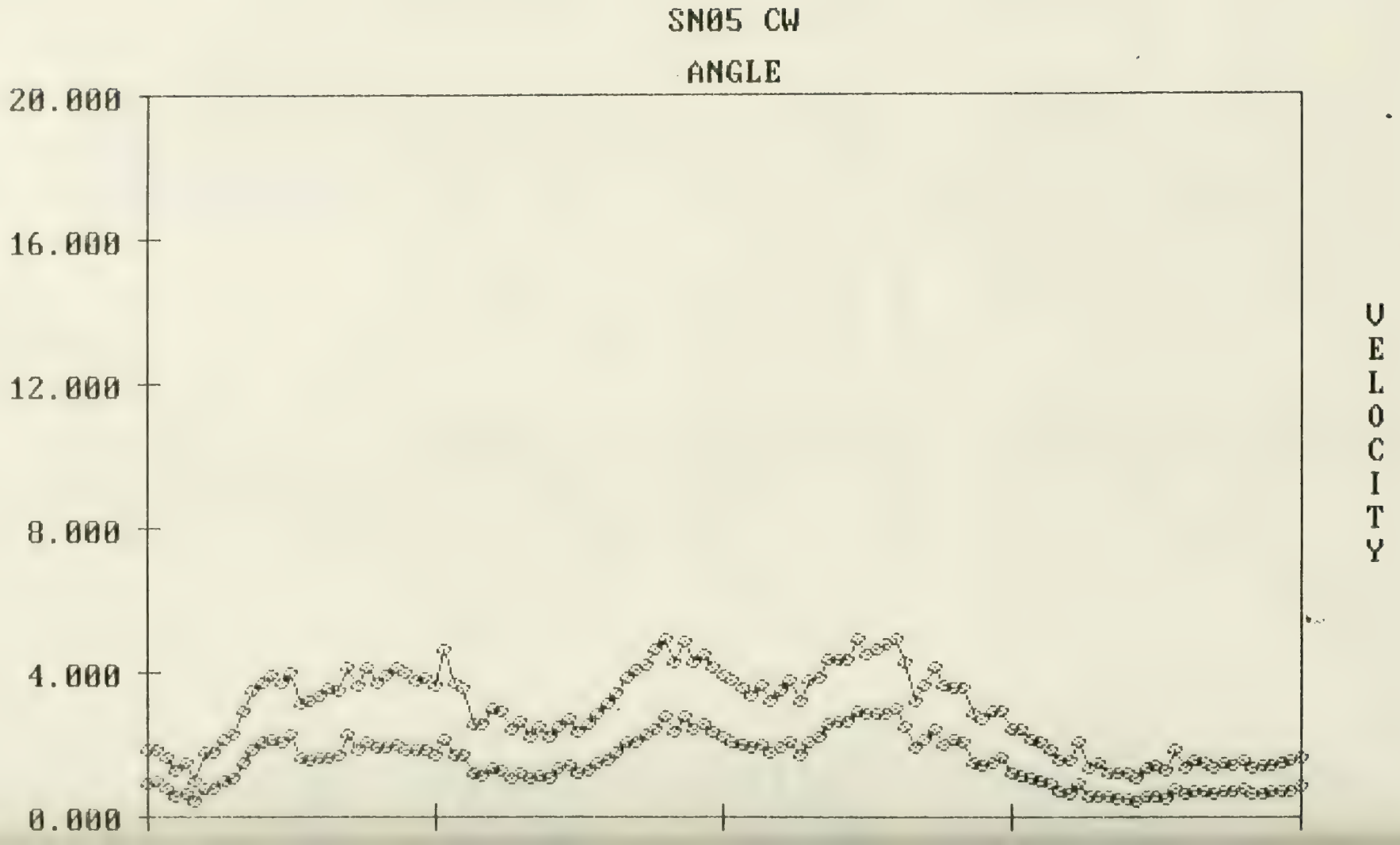
bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.663	2.940	2.703	2.366	2.665
20%	4.455	4.765	4.576	3.996	4.452
10%	5.733	6.017	5.907	5.096	5.702
5%	6.962	7.328	7.226	6.118	6.920
1%	9.793	10.638	10.228	8.372	9.839

Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.167	3.430	3.201	2.868	3.164
20%	5.569	5.767	5.671	5.130	5.525
10%	7.507	7.630	7.677	6.697	7.402
5%	9.504	9.776	9.850	8.394	9.379
1%	14.773	16.417	15.648	12.639	14.939

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.957	6.578	6.046	5.293	5.962
20%	9.966	10.659	10.236	8.939	9.960
10%	12.825	13.460	13.213	11.399	12.754
5%	15.572	16.392	16.164	13.687	15.480
1%	21.905	23.796	22.879	18.728	22.009


SN05 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.781711	0.944212
1.00	0.464644	0.797955
1.50	0.286708	0.621369
2.00	0.181509	0.466033
2.50	0.113523	0.348298
3.00	0.069794	0.262107
3.50	0.042103	0.197635
4.00	0.024878	0.148326
4.50	0.014379	0.110442
5.00	0.008122	0.081527
5.50	0.004483	0.059672
6.00	0.002419	0.043314
6.50	0.001276	0.031181
7.00	0.000658	0.022261
7.50	0.000332	0.015760
8.00	0.000164	0.011063
8.50	0.000079	0.007699
9.00	0.000037	0.005311
9.50	0.000017	0.003633
10.00	0.000008	0.002463
10.50	0.000003	0.001656
11.00	0.000001	0.001104
11.50	0.000001	0.000730
12.00	0.000000	0.000479
12.50	0.000000	0.000312
13.00	0.000000	0.000201
13.50	0.000000	0.000129
14.00	0.000000	0.000082
14.50	0.000000	0.000052
15.00	0.000000	0.000032
15.50	0.000000	0.000020
16.00	0.000000	0.000012
16.50	0.000000	0.000008
17.00	0.000000	0.000005
17.50	0.000000	0.000003
18.00	0.000000	0.000002
18.50	0.000000	0.000001
19.00	0.000000	0.000001
19.50	0.000000	0.000000
20.00	0.000000	0.000000
20.50	0.000000	0.000000
21.00	0.000000	0.000000
21.50	0.000000	0.000000
22.00	0.000000	0.000000
22.50	0.000000	0.000000
23.00	0.000000	0.000000
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	0.970	0.935	0.954	0.919	0.944
20%	2.021	1.838	1.922	1.866	1.912
10%	2.795	2.638	2.658	2.506	2.655
5%	3.474	3.441	3.349	3.142	3.357
1%	4.940	5.178	4.817	4.399	4.850

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.929	1.925	1.922	1.777	1.891
20%	3.699	3.410	3.540	3.323	3.482
10%	4.931	4.676	4.735	4.374	4.681
5%	6.059	5.935	5.823	5.339	5.796
1%	8.392	8.681	8.096	7.325	8.158

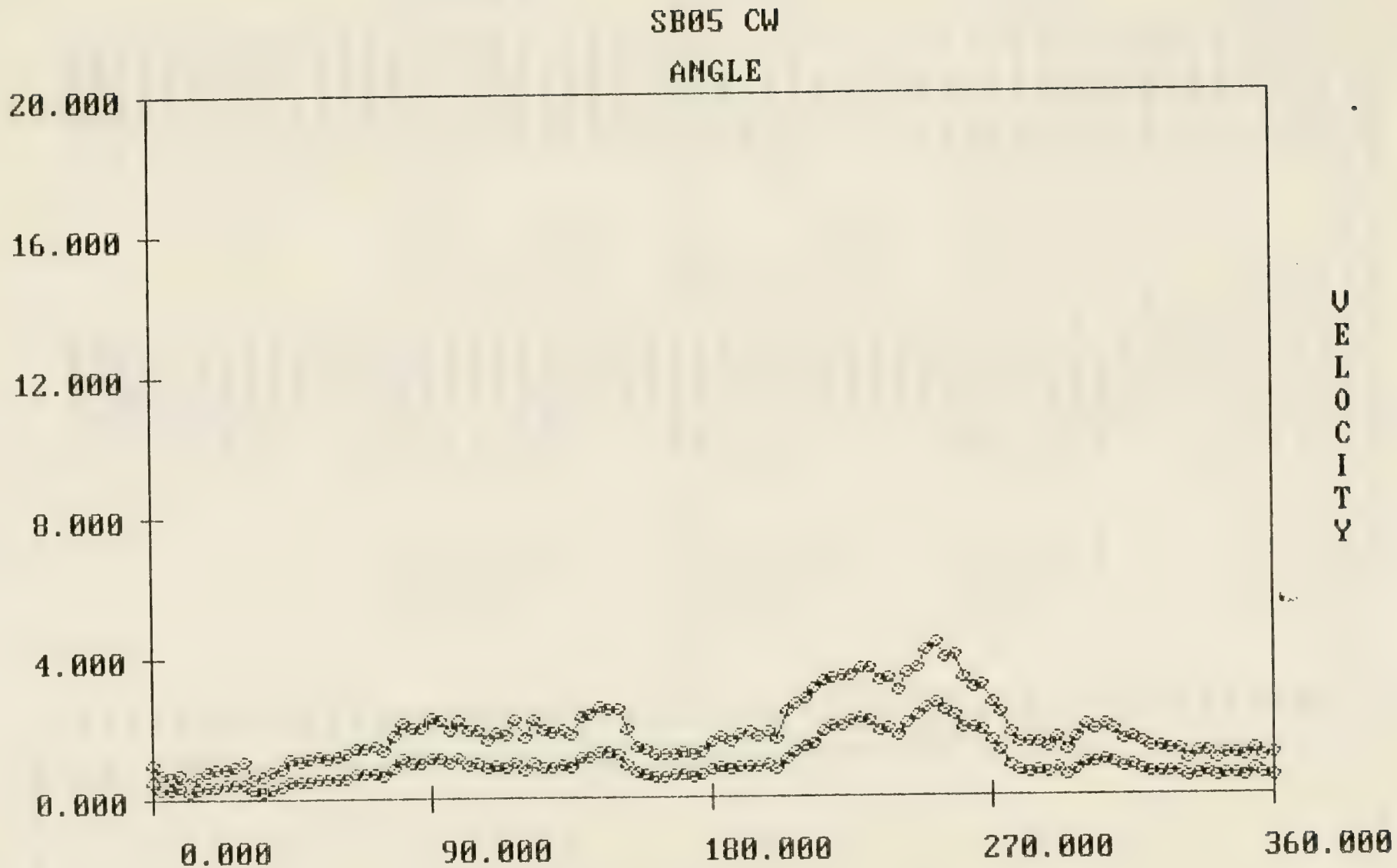
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.170	2.091	2.133	2.057	2.112
20%	4.520	4.111	4.300	4.173	4.277
10%	6.253	5.900	5.947	5.605	5.938
5%	7.772	7.697	7.491	7.030	7.510
1%	11.050	11.582	10.774	9.841	10.849

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.316	4.306	4.299	3.975	4.229
20%	8.273	7.629	7.920	7.434	7.788
10%	11.031	10.461	10.592	9.784	10.470
5%	13.554	13.277	13.025	11.943	12.964
1%	18.773	19.419	18.109	16.386	18.249

sn05


SB05 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.675987	0.883230
1.00	0.363619	0.676449
1.50	0.212023	0.489979
2.00	0.133262	0.349252
2.50	0.082801	0.250491
3.00	0.049030	0.182102
3.50	0.027521	0.133633
4.00	0.014704	0.098042
4.50	0.007517	0.071274
5.00	0.003693	0.051050
5.50	0.001747	0.035930
6.00	0.000797	0.024832
6.50	0.000351	0.016857
7.00	0.000149	0.011249
7.50	0.000061	0.007386
8.00	0.000024	0.004775
8.50	0.000009	0.003041
9.00	0.000003	0.001909
9.50	0.000001	0.001181
10.00	0.000000	0.000720
10.50	0.000000	0.000433
11.00	0.000000	0.000257
11.50	0.000000	0.000150
12.00	0.000000	0.000086
12.50	0.000000	0.000049
13.00	0.000000	0.000027
13.50	0.000000	0.000015
14.00	0.000000	0.000008
14.50	0.000000	0.000004
15.00	0.000000	0.000002
15.50	0.000000	0.000001
16.00	0.000000	0.000001
16.50	0.000000	0.000000
17.00	0.000000	0.000000
17.50	0.000000	0.000000
18.00	0.000000	0.000000
18.50	0.000000	0.000000
19.00	0.000000	0.000000
19.50	0.000000	0.000000
20.00	0.000000	0.000000
20.50	0.000000	0.000000
21.00	0.000000	0.000000
21.50	0.000000	0.000000
22.00	0.000000	0.000000
22.50	0.000000	0.000000
23.00	0.000000	0.000000
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

\nb17\sb05

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	0.780	0.848	0.768	0.722	0.782
20%	1.629	1.629	1.492	1.556	1.576
10%	2.394	2.403	2.268	2.254	2.330
5%	3.049	3.161	2.983	2.823	2.986
1%	4.332	4.580	4.412	3.888	4.327

Vguat (m/s)

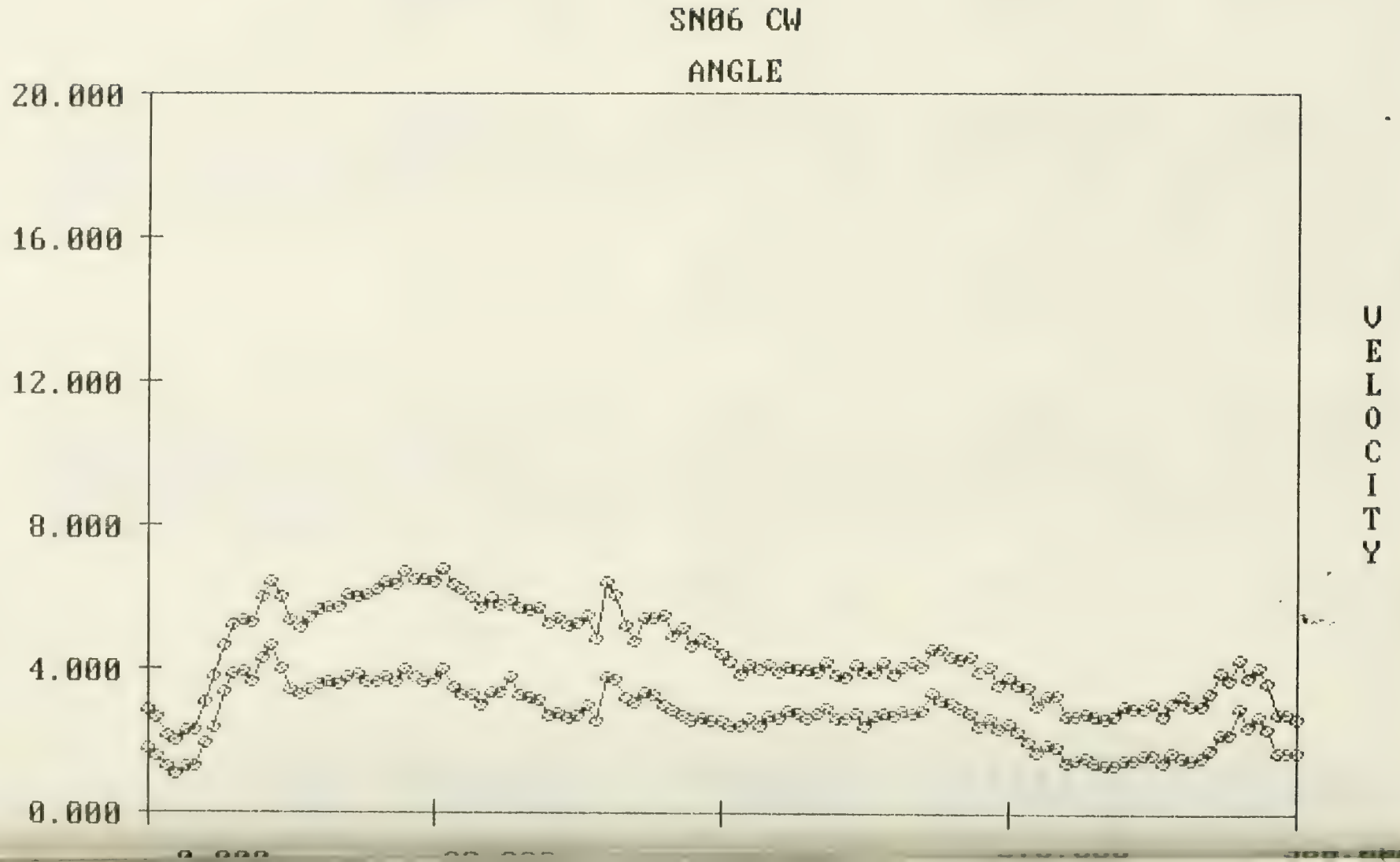
bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.467	1.650	1.456	1.343	1.473
20%	2.927	2.982	2.805	2.734	2.869
10%	4.115	4.130	3.911	3.784	3.972
5%	5.181	5.301	5.028	4.691	5.035
1%	7.208	7.597	7.307	6.404	7.162

Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.745	1.897	1.717	1.616	1.749
20%	3.643	3.645	3.338	3.481	3.526
10%	5.355	5.374	5.073	5.043	5.211
5%	6.820	7.072	6.672	6.314	6.679
1%	9.689	10.244	9.869	8.697	9.680

Vguat (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.282	3.691	3.256	3.004	3.295
20%	6.547	6.671	6.275	6.115	6.418
10%	9.204	9.239	8.749	8.465	8.886
5%	11.590	11.858	11.247	10.493	11.262
1%	16.125	16.995	16.346	14.324	16.020


SN06 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.946770	0.980876
1.00	0.805782	0.926562
1.50	0.624428	0.843317
2.00	0.450385	0.740626
2.50	0.309526	0.628934
3.00	0.206253	0.517698
3.50	0.134317	0.414191
4.00	0.085590	0.323052
4.50	0.053365	0.246416
5.00	0.032623	0.184413
5.50	0.019648	0.135832
6.00	0.011740	0.098760
6.50	0.007023	0.071073
7.00	0.004248	0.050755
7.50	0.002625	0.036059
8.00	0.001673	0.025556
8.50	0.001105	0.018126
9.00	0.000757	0.012913
9.50	0.000536	0.009279
10.00	0.000389	0.006753
10.50	0.000287	0.004999
11.00	0.000214	0.003775
11.50	0.000160	0.002915
12.00	0.000120	0.002300
12.50	0.000090	0.001853
13.00	0.000067	0.001519
13.50	0.000050	0.001264
14.00	0.000037	0.001063
14.50	0.000027	0.000902
15.00	0.000019	0.000768
15.50	0.000014	0.000657
16.00	0.000010	0.000562
16.50	0.000007	0.000481
17.00	0.000005	0.000412
17.50	0.000004	0.000352
18.00	0.000002	0.000300
18.50	0.000002	0.000256
19.00	0.000001	0.000217
19.50	0.000001	0.000184
20.00	0.000001	0.000156
20.50	0.000000	0.000132
21.00	0.000000	0.000111
21.50	0.000000	0.000093
22.00	0.000000	0.000078
22.50	0.000000	0.000065
23.00	0.000000	0.000054
23.50	0.000000	0.000045
24.00	0.000000	0.000037
24.50	0.000000	0.000031
25.00	0.000000	0.000025

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.879	1.972	1.922	1.653	1.857
20%	3.179	3.123	3.160	2.762	3.043
10%	4.043	3.910	3.952	3.450	3.852
5%	4.872	4.668	4.697	4.075	4.581
1%	6.802	6.255	6.186	5.343	6.184

Vguat (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.104	3.360	3.214	2.694	3.085
20%	4.989	5.085	5.075	4.298	4.874
10%	6.267	6.154	6.228	5.282	5.983
5%	7.494	7.142	7.265	6.152	7.026
1%	11.023	9.267	9.392	7.900	9.401

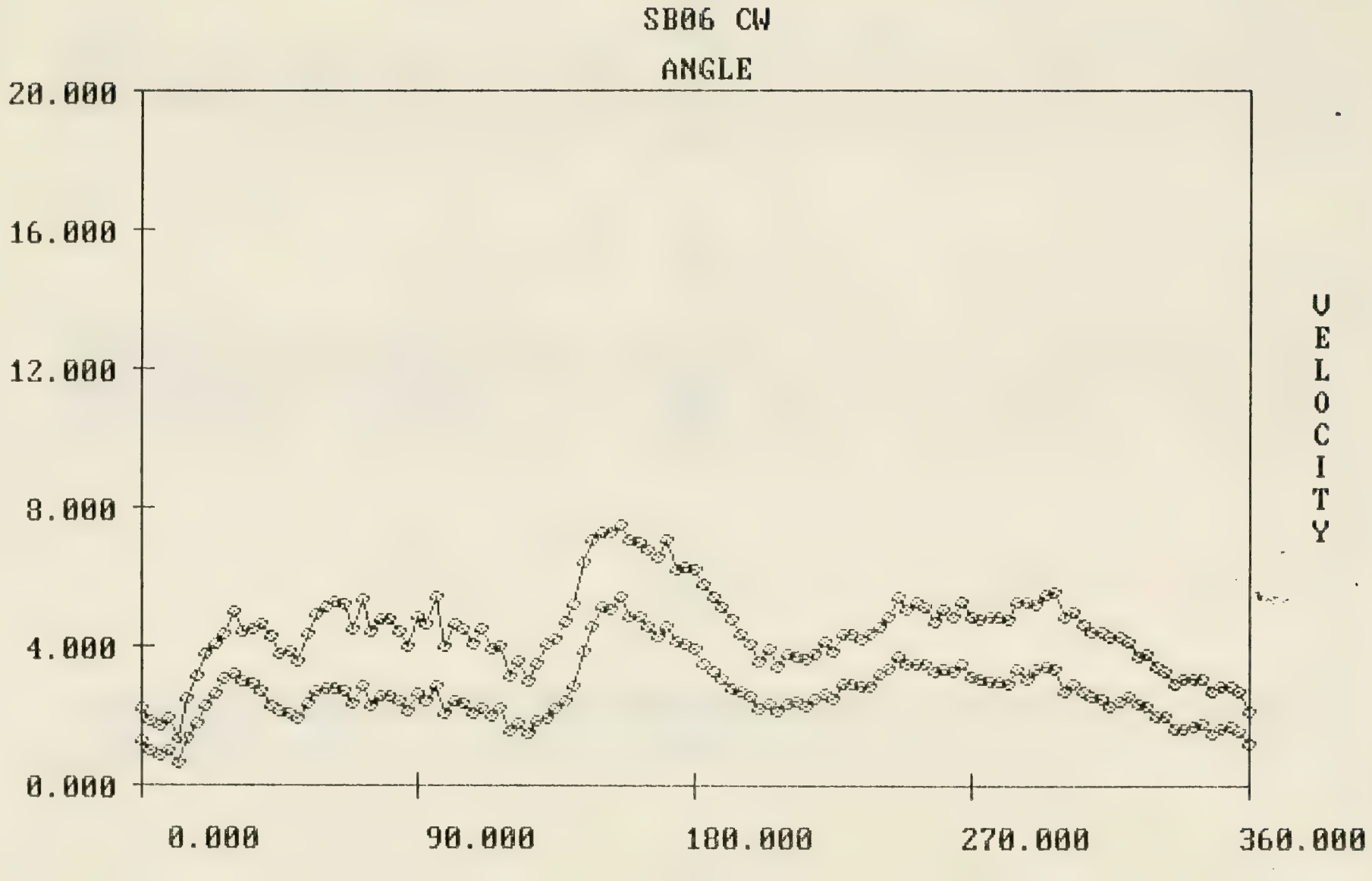
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.202	4.411	4.299	3.698	4.155
20%	7.110	6.985	7.068	6.177	6.808
10%	9.044	8.746	8.839	7.717	8.617
5%	10.899	10.442	10.506	9.115	10.248
1%	15.215	13.993	13.837	11.952	13.834

Vguat (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.943	7.516	7.189	6.026	6.902
20%	11.160	11.374	11.353	9.615	10.904
10%	14.019	13.766	13.932	11.815	13.384
5%	16.765	15.975	16.251	13.762	15.716
1%	24.658	20.729	21.010	17.671	21.029

\nb17\sn06


SB06 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.949691	0.981715
1.00	0.833238	0.932903
1.50	0.691317	0.862302
2.00	0.548485	0.778558
2.50	0.419378	0.688608
3.00	0.310603	0.597750
3.50	0.223344	0.509991
4.00	0.156063	0.428195
4.50	0.106044	0.354170
5.00	0.070137	0.288823
5.50	0.045204	0.232360
6.00	0.028424	0.184492
6.50	0.017459	0.144614
7.00	0.010489	0.111932
7.50	0.006171	0.085567
8.00	0.003561	0.064619
8.50	0.002019	0.048222
9.00	0.001126	0.035569
9.50	0.000618	0.025943
10.00	0.000335	0.018718
10.50	0.000179	0.013366
11.00	0.000095	0.009451
11.50	0.000050	0.006621
12.00	0.000026	0.004599
12.50	0.000014	0.003170
13.00	0.000007	0.002170
13.50	0.000004	0.001476
14.00	0.000002	0.000999
14.50	0.000001	0.000673
15.00	0.000001	0.000453
15.50	0.000000	0.000303
16.00	0.000000	0.000203
16.50	0.000000	0.000136
17.00	0.000000	0.000091
17.50	0.000000	0.000061
18.00	0.000000	0.000041
18.50	0.000000	0.000028
19.00	0.000000	0.000019
19.50	0.000000	0.000013
20.00	0.000000	0.000009
20.50	0.000000	0.000006
21.00	0.000000	0.000004
21.50	0.000000	0.000003
22.00	0.000000	0.000002
22.50	0.000000	0.000001
23.00	0.000000	0.000001
23.50	0.000000	0.000001
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.175	2.513	2.198	1.904	2.188
20%	3.598	4.119	3.736	3.208	3.673
10%	4.470	5.044	4.720	3.981	4.584
5%	5.277	5.862	5.604	4.694	5.404
1%	6.884	7.455	7.413	6.052	7.057

Vguat (m/s)

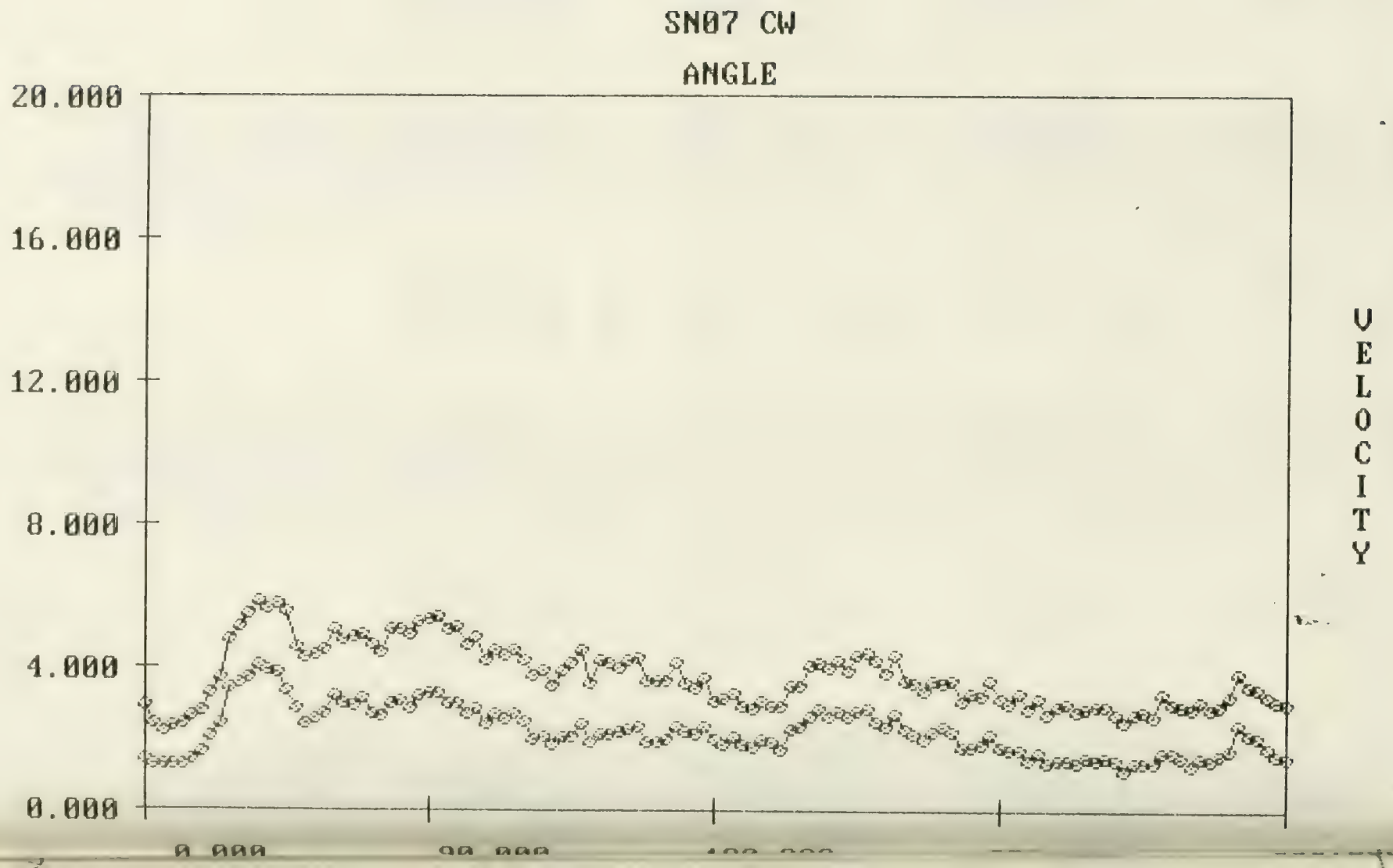
bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.551	4.104	3.611	3.072	3.561
20%	5.761	6.562	5.964	5.005	5.838
10%	7.085	7.975	7.441	6.172	7.226
5%	8.277	9.193	8.774	7.180	8.446
1%	10.736	11.522	11.438	9.168	10.930

Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.865	5.622	4.917	4.260	4.894
20%	8.049	9.214	8.357	7.177	8.217
10%	10.000	11.283	10.559	8.904	10.254
5%	11.805	13.113	12.535	10.500	12.088
1%	15.399	16.676	16.583	13.538	15.785

Vguat (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.944	9.180	8.078	6.872	7.966
20%	12.887	14.679	13.340	11.196	13.059
10%	15.849	17.840	16.646	13.807	16.165
5%	18.514	20.564	19.627	16.062	18.893
1%	24.016	25.773	25.586	20.507	24.449


SN07 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.928592	0.976441
1.00	0.747192	0.911294
1.50	0.529368	0.813531
2.00	0.340270	0.695608
2.50	0.205564	0.570782
3.00	0.120262	0.450582
3.50	0.069326	0.343243
4.00	0.039593	0.253242
4.50	0.022408	0.181729
5.00	0.012576	0.127456
5.50	0.007019	0.087820
6.00	0.003917	0.059757
6.50	0.002200	0.040354
7.00	0.001253	0.027161
7.50	0.000728	0.018286
8.00	0.000434	0.012349
8.50	0.000266	0.008388
9.00	0.000167	0.005743
9.50	0.000106	0.003974
10.00	0.000069	0.002784
10.50	0.000045	0.001980
11.00	0.000029	0.001430
11.50	0.000019	0.001049
12.00	0.000012	0.000782
12.50	0.000008	0.000591
13.00	0.000005	0.000452
13.50	0.000003	0.000349
14.00	0.000002	0.000271
14.50	0.000001	0.000212
15.00	0.000001	0.000166
15.50	0.000000	0.000130
16.00	0.000000	0.000102
16.50	0.000000	0.000080
17.00	0.000000	0.000062
17.50	0.000000	0.000049
18.00	0.000000	0.000038
18.50	0.000000	0.000029
19.00	0.000000	0.000023
19.50	0.000000	0.000017
20.00	0.000000	0.000013
20.50	0.000000	0.000010
21.00	0.000000	0.000008
21.50	0.000000	0.000006
22.00	0.000000	0.000004
22.50	0.000000	0.000003
23.00	0.000000	0.000002
23.50	0.000000	0.000002
24.00	0.000000	0.000001
24.50	0.000000	0.000001
25.00	0.000000	0.000001

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.596	1.702	1.635	1.389	1.578
20%	2.633	2.618	2.637	2.295	2.533
10%	3.361	3.242	3.297	2.875	3.199
5%	4.049	3.857	3.902	3.414	3.825
1%	5.677	5.317	5.206	4.545	5.232

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.810	3.079	2.890	2.418	2.794
20%	4.446	4.616	4.519	3.840	4.372
10%	5.507	5.525	5.507	4.709	5.346
5%	6.560	6.390	6.412	5.477	6.251
1%	9.180	8.351	8.279	7.143	8.297

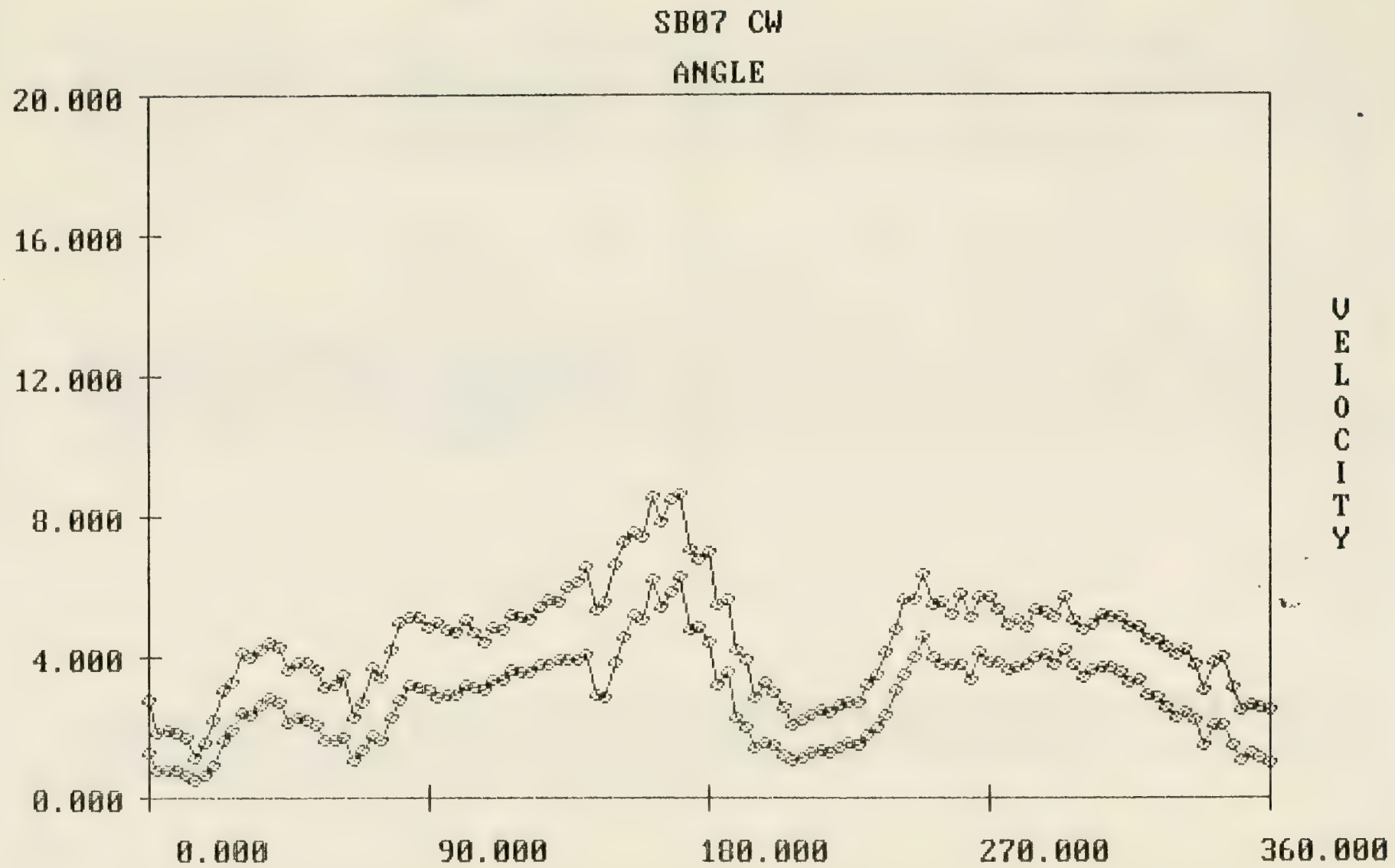
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.570	3.807	3.657	3.108	3.529
20%	5.890	5.856	5.898	5.134	5.665
10%	7.519	7.252	7.376	6.432	7.156
5%	9.058	8.629	8.728	7.636	8.556
1%	12.700	11.895	11.645	10.167	11.703

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.285	6.888	6.464	5.408	6.251
20%	9.946	10.325	10.109	8.589	9.780
10%	12.319	12.359	12.319	10.535	11.959
5%	14.674	14.295	14.343	12.251	13.984
1%	20.535	18.680	18.519	15.978	18.559

\nb17\sn07


SB07 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.930037	0.978158
1.00	0.795807	0.921743
1.50	0.659472	0.843734
2.00	0.538973	0.755603
2.50	0.436463	0.665468
3.00	0.349504	0.578404
3.50	0.275728	0.497209
4.00	0.213644	0.423186
4.50	0.162243	0.356753
5.00	0.120610	0.297851
5.50	0.087731	0.246191
6.00	0.062459	0.201380
6.50	0.043563	0.162969
7.00	0.029812	0.130464
7.50	0.020062	0.103322
8.00	0.013312	0.080970
8.50	0.008739	0.062816
9.00	0.005698	0.048270
9.50	0.003705	0.036769
10.00	0.002413	0.027789
10.50	0.001580	0.020860
11.00	0.001044	0.015570
11.50	0.000698	0.011572
12.00	0.000473	0.008576
12.50	0.000325	0.006346
13.00	0.000226	0.004696
13.50	0.000159	0.003480
14.00	0.000113	0.002586
14.50	0.000081	0.001929
15.00	0.000058	0.001446
15.50	0.000042	0.001090
16.00	0.000030	0.000827
16.50	0.000022	0.000632
17.00	0.000016	0.000486
17.50	0.000011	0.000376
18.00	0.000008	0.000293
18.50	0.000006	0.000229
19.00	0.000004	0.000180
19.50	0.000003	0.000142
20.00	0.000002	0.000113
20.50	0.000001	0.000090
21.00	0.000001	0.000072
21.50	0.000001	0.000057
22.00	0.000000	0.000046
22.50	0.000000	0.000037
23.00	0.000000	0.000029
23.50	0.000000	0.000023
24.00	0.000000	0.000019
24.50	0.000000	0.000015
25.00	0.000000	0.000012

\nb17\sb07

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.124	2.704	2.206	1.824	2.190
20%	4.009	4.780	4.208	3.455	4.133
10%	5.184	5.920	5.467	4.458	5.313
5%	6.212	6.878	6.572	5.323	6.330
1%	8.423	8.722	8.738	6.953	8.362

Vgust (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.425	4.170	3.541	2.927	3.483
20%	5.901	6.846	6.165	5.070	6.018
10%	7.443	8.360	7.819	6.399	7.574
5%	8.854	9.647	9.285	7.550	8.941
1%	12.015	12.197	12.223	9.843	11.762

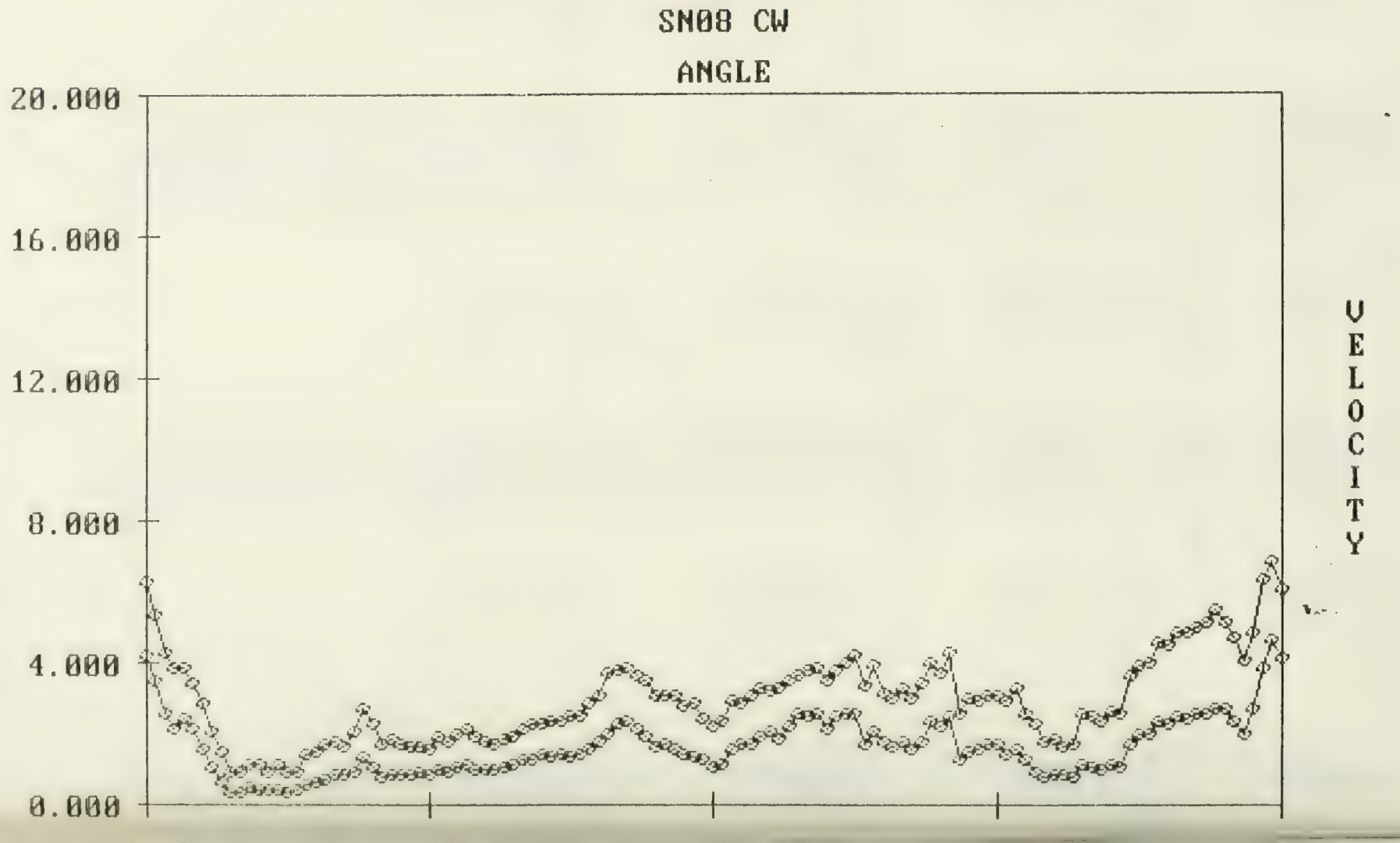
Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.752	6.048	4.935	4.080	4.899
20%	8.969	10.691	9.412	7.730	9.245
10%	11.597	13.243	12.229	9.972	11.886
5%	13.897	15.386	14.701	11.907	14.159
1%	18.841	19.510	19.545	15.554	18.706

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.662	9.328	7.920	6.548	7.791
20%	13.200	15.315	13.792	11.340	13.462
10%	16.650	18.700	17.492	14.315	16.943
5%	19.807	21.579	20.770	16.890	19.999
1%	26.876	27.284	27.343	22.019	26.312

17\sb07


SN08 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.850131	0.953026
1.00	0.620321	0.848573
1.50	0.421668	0.727321
2.00	0.274777	0.606919
2.50	0.172485	0.494708
3.00	0.104126	0.394763
3.50	0.060523	0.309039
4.00	0.034020	0.237821
4.50	0.018609	0.180222
5.00	0.009980	0.134685
5.50	0.005292	0.099370
6.00	0.002796	0.072425
6.50	0.001480	0.052156
7.00	0.000786	0.037104
7.50	0.000418	0.026066
8.00	0.000222	0.018077
8.50	0.000117	0.012371
9.00	0.000060	0.008351
9.50	0.000031	0.005560
10.00	0.000015	0.003651
10.50	0.000007	0.002364
11.00	0.000004	0.001510
11.50	0.000002	0.000951
12.00	0.000001	0.000591
12.50	0.000000	0.000363
13.00	0.000000	0.000220
13.50	0.000000	0.000132
14.00	0.000000	0.000078
14.50	0.000000	0.000046
15.00	0.000000	0.000027
15.50	0.000000	0.000015
16.00	0.000000	0.000009
16.50	0.000000	0.000005
17.00	0.000000	0.000003
17.50	0.000000	0.000002
18.00	0.000000	0.000001
18.50	0.000000	0.000000
19.00	0.000000	0.000000
19.50	0.000000	0.000000
20.00	0.000000	0.000000
20.50	0.000000	0.000000
21.00	0.000000	0.000000
21.50	0.000000	0.000000
22.00	0.000000	0.000000
22.50	0.000000	0.000000
23.00	0.000000	0.000000
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.303	1.473	1.327	1.110	1.303
20%	2.384	2.597	2.430	2.014	2.366
10%	3.067	3.340	3.152	2.623	3.047
5%	3.706	3.981	3.795	3.171	3.699
1%	4.991	5.392	5.074	4.347	4.999

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.463	2.896	2.518	2.091	2.476
20%	4.314	4.837	4.464	3.659	4.328
10%	5.467	6.064	5.700	4.635	5.491
5%	6.510	7.189	6.800	5.504	6.572
1%	8.676	9.410	8.994	7.392	8.795

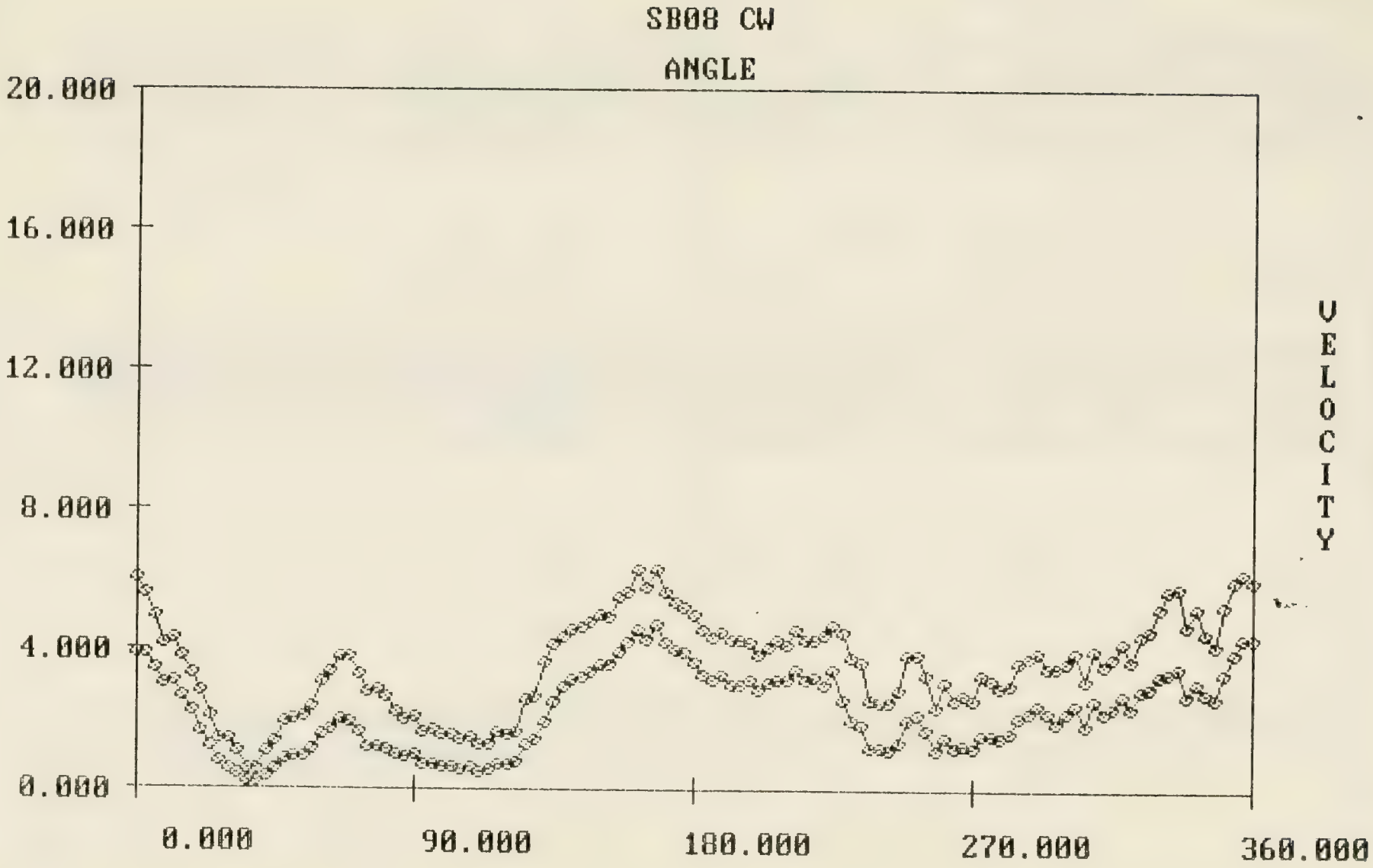
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.914	3.294	2.968	2.484	2.914
20%	5.332	5.809	5.435	4.504	5.291
10%	6.861	7.471	7.051	5.868	6.817
5%	8.289	8.906	8.488	7.093	8.273
1%	11.164	12.061	11.350	9.724	11.182

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.509	6.477	5.632	4.678	5.540
20%	9.649	10.819	9.987	8.185	9.682
10%	12.230	13.565	12.751	10.368	12.283
5%	14.563	16.080	15.212	12.311	14.700
1%	19.407	21.051	20.119	16.535	19.674

\nb17\sn08


SB08 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.895272	0.962859
1.00	0.734304	0.887021
1.50	0.566504	0.793591
2.00	0.415229	0.691786
2.50	0.291967	0.588000
3.00	0.197951	0.487492
3.50	0.129721	0.394583
4.00	0.082376	0.312230
4.50	0.050859	0.241898
5.00	0.030639	0.183771
5.50	0.018071	0.137099
6.00	0.010461	0.100576
6.50	0.005956	0.072647
7.00	0.003340	0.051730
7.50	0.001847	0.036357
8.00	0.001009	0.025248
8.50	0.000546	0.017342
9.00	0.000293	0.011791
9.50	0.000156	0.007941
10.00	0.000083	0.005300
10.50	0.000044	0.003507
11.00	0.000023	0.002300
11.50	0.000012	0.001495
12.00	0.000006	0.000964
12.50	0.000003	0.000616
13.00	0.000002	0.000390
13.50	0.000001	0.000245
14.00	0.000000	0.000152
14.50	0.000000	0.000094
15.00	0.000000	0.000058
15.50	0.000000	0.000035
16.00	0.000000	0.000021
16.50	0.000000	0.000013
17.00	0.000000	0.000008
17.50	0.000000	0.000005
18.00	0.000000	0.000003
18.50	0.000000	0.000002
19.00	0.000000	0.000001
19.50	0.000000	0.000001
20.00	0.000000	0.000000
20.50	0.000000	0.000000
21.00	0.000000	0.000000
21.50	0.000000	0.000000
22.00	0.000000	0.000000
22.50	0.000000	0.000000
23.00	0.000000	0.000000
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

\nb17\sb08

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.685	2.035	1.791	1.419	1.720
20%	2.935	3.380	3.143	2.474	2.989
10%	3.752	4.199	3.950	3.185	3.814
5%	4.474	4.925	4.685	3.827	4.521
1%	6.048	6.490	6.144	5.182	6.051

Vgust (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.897	3.476	3.027	2.456	2.938
20%	4.765	5.472	5.056	4.043	4.860
10%	5.898	6.655	6.260	5.004	6.010
5%	6.931	7.702	7.309	5.895	7.056
1%	9.136	9.874	9.424	7.749	9.233

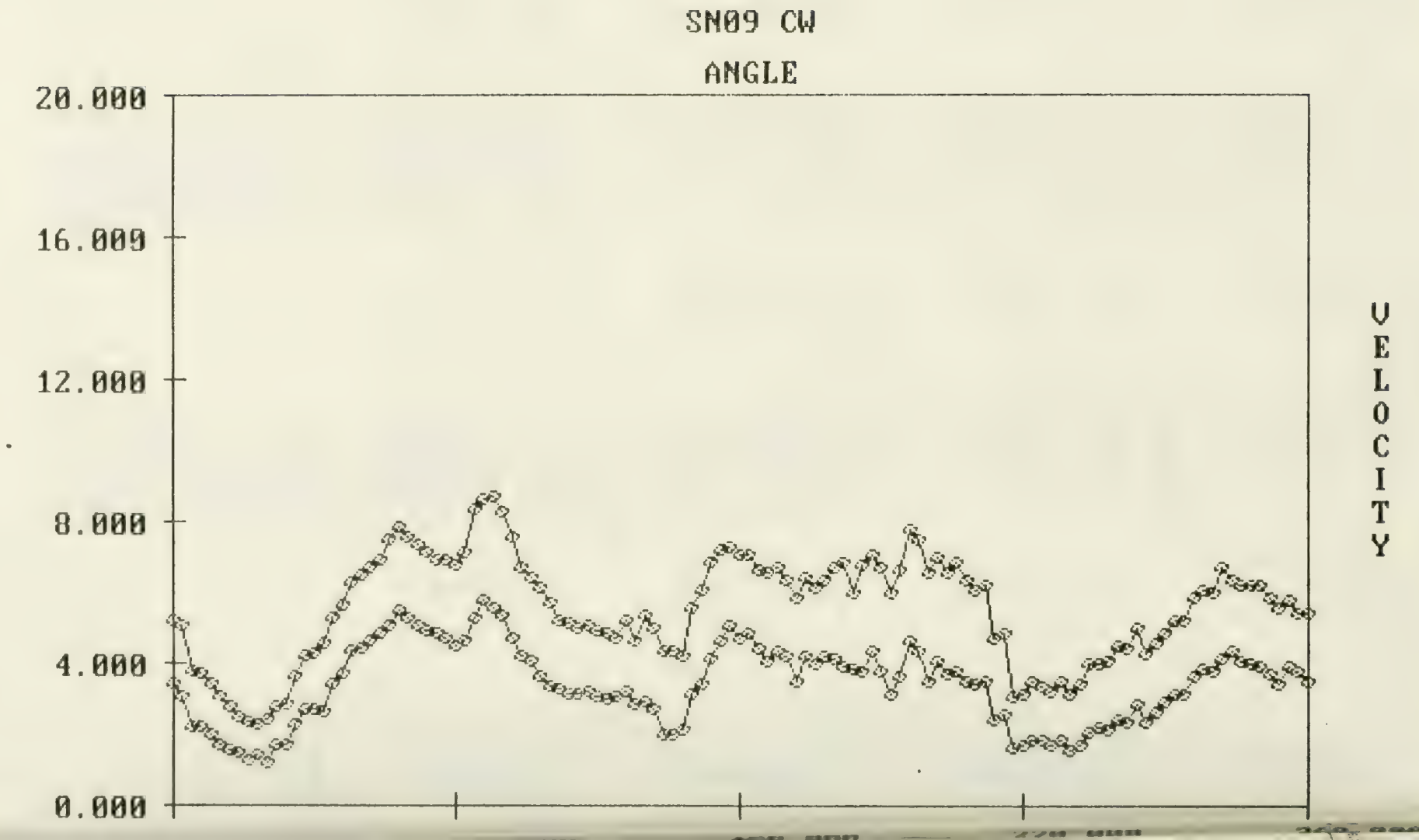
Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.770	4.552	4.006	3.175	3.847
20%	6.564	7.561	7.030	5.534	6.686
10%	8.393	9.394	8.836	7.124	8.531
5%	10.008	11.017	10.480	8.560	10.114
1%	13.529	14.518	13.743	11.592	13.536

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.479	7.775	6.772	5.493	6.572
20%	10.658	12.240	11.311	9.044	10.872
10%	13.194	14.886	14.003	11.194	13.445
5%	15.504	17.229	16.351	13.186	15.784
1%	20.436	22.088	21.081	17.334	20.653

7\sb08


SN09 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.964186	0.987280
1.00	0.872010	0.952855
1.50	0.747533	0.900575
2.00	0.614222	0.835043
2.50	0.488487	0.761008
3.00	0.378864	0.682802
3.50	0.287976	0.604055
4.00	0.215075	0.527615
4.50	0.158005	0.455571
5.00	0.114251	0.389313
5.50	0.081372	0.329622
6.00	0.057146	0.276779
6.50	0.039635	0.230686
7.00	0.027204	0.190984
7.50	0.018524	0.157157
8.00	0.012552	0.128607
8.50	0.008491	0.104713
9.00	0.005756	0.084865
9.50	0.003922	0.068492
10.00	0.002696	0.055070
10.50	0.001873	0.044128
11.00	0.001317	0.035255
11.50	0.000938	0.028094
12.00	0.000676	0.022338
12.50	0.000492	0.017729
13.00	0.000361	0.014052
13.50	0.000267	0.011126
14.00	0.000198	0.008805
14.50	0.000148	0.006966
15.00	0.000110	0.005514
15.50	0.000082	0.004367
16.00	0.000061	0.003462
16.50	0.000045	0.002749
17.00	0.000034	0.002187
17.50	0.000025	0.001743
18.00	0.000018	0.001393
18.50	0.000013	0.001116
19.00	0.000010	0.000896
19.50	0.000007	0.000722
20.00	0.000005	0.000583
20.50	0.000004	0.000473
21.00	0.000003	0.000384
21.50	0.000002	0.000313
22.00	0.000001	0.000255
22.50	0.000001	0.000209
23.00	0.000001	0.000171
23.50	0.000000	0.000141
24.00	0.000000	0.000115
24.50	0.000000	0.000095
25.00	0.000000	0.000078

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.498	2.665	2.558	2.130	2.454
20%	4.290	4.340	4.279	3.609	4.132
10%	5.450	5.431	5.351	4.546	5.217
5%	6.527	6.444	6.312	5.391	6.204
1%	8.994	8.598	8.242	7.050	8.314

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.245	4.598	4.335	3.629	4.192
20%	7.073	7.293	7.084	6.026	6.886
10%	8.952	9.022	8.793	7.581	8.619
5%	10.741	10.673	10.336	8.987	10.232
1%	14.774	14.303	13.545	11.868	13.743

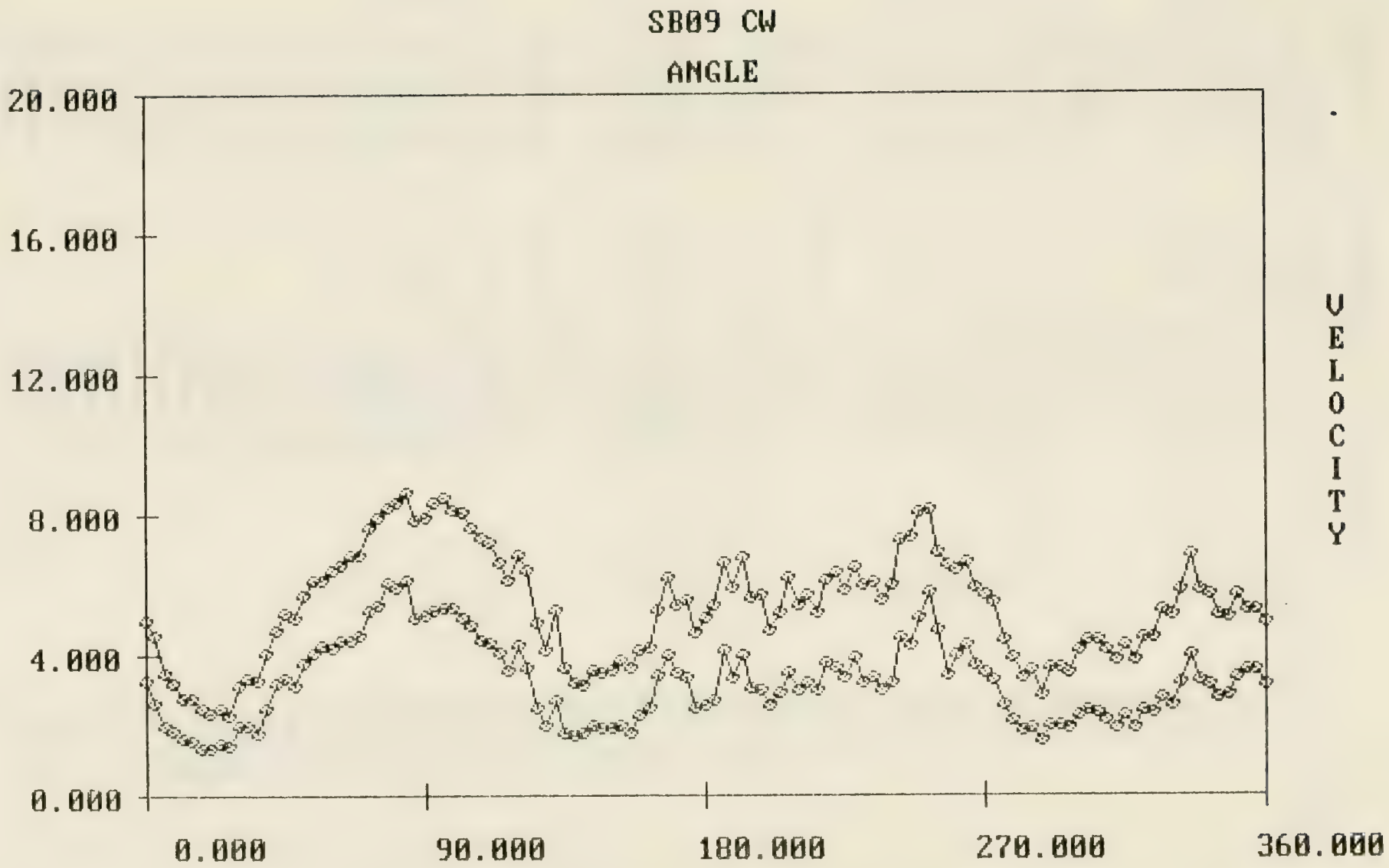
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.588	5.961	5.721	4.764	5.490
20%	9.596	9.708	9.572	8.073	9.243
10%	12.192	12.149	11.971	10.168	11.669
5%	14.601	14.415	14.119	12.059	13.878
1%	20.118	19.233	18.436	15.771	18.598

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	9.496	10.286	9.698	8.117	9.376
20%	15.821	16.313	15.847	13.479	15.405
10%	20.025	20.181	19.669	16.958	19.280
5%	24.027	23.875	23.120	20.103	22.888
1%	33.048	31.995	30.300	26.548	30.741

\nb17\sn09


SB09 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.961903	0.986682
1.00	0.865468	0.951266
1.50	0.735957	0.897940
2.00	0.597658	0.831442
2.50	0.468018	0.756561
3.00	0.356647	0.677616
3.50	0.266701	0.598214
4.00	0.197076	0.521199
4.50	0.144615	0.448688
5.00	0.105701	0.382128
5.50	0.077082	0.322362
6.00	0.056133	0.269714
6.50	0.040844	0.224093
7.00	0.029707	0.185108
7.50	0.021608	0.152176
8.00	0.015723	0.124617
8.50	0.011448	0.101727
9.00	0.008344	0.082825
9.50	0.006087	0.067289
10.00	0.004445	0.054566
10.50	0.003249	0.044175
11.00	0.002377	0.035712
11.50	0.001740	0.028833
12.00	0.001274	0.023252
12.50	0.000933	0.018734
13.00	0.000683	0.015081
13.50	0.000500	0.012134
14.00	0.000366	0.009759
14.50	0.000268	0.007848
15.00	0.000196	0.006312
15.50	0.000144	0.005079
16.00	0.000105	0.004089
16.50	0.000077	0.003295
17.00	0.000056	0.002659
17.50	0.000041	0.002148
18.00	0.000030	0.001738
18.50	0.000022	0.001409
19.00	0.000016	0.001145
19.50	0.000012	0.000932
20.00	0.000009	0.000760
20.50	0.000006	0.000622
21.00	0.000005	0.000510
21.50	0.000003	0.000419
22.00	0.000002	0.000345
22.50	0.000002	0.000285
23.00	0.000001	0.000236
23.50	0.000001	0.000196
24.00	0.000001	0.000163
24.50	0.000001	0.000135
25.00	0.000000	0.000113

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.399	2.584	2.432	2.094	2.377
20%	4.111	4.156	4.078	3.582	3.979
10%	5.336	5.264	5.210	4.586	5.100
5%	6.523	6.369	6.312	5.516	6.201
1%	9.377	8.905	8.820	7.571	8.733

Vgust (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.178	4.556	4.248	3.628	4.146
20%	6.965	7.182	6.972	6.039	6.809
10%	8.874	8.909	8.730	7.611	8.546
5%	10.719	10.595	10.378	9.047	10.220
1%	14.974	14.349	14.002	12.041	13.949

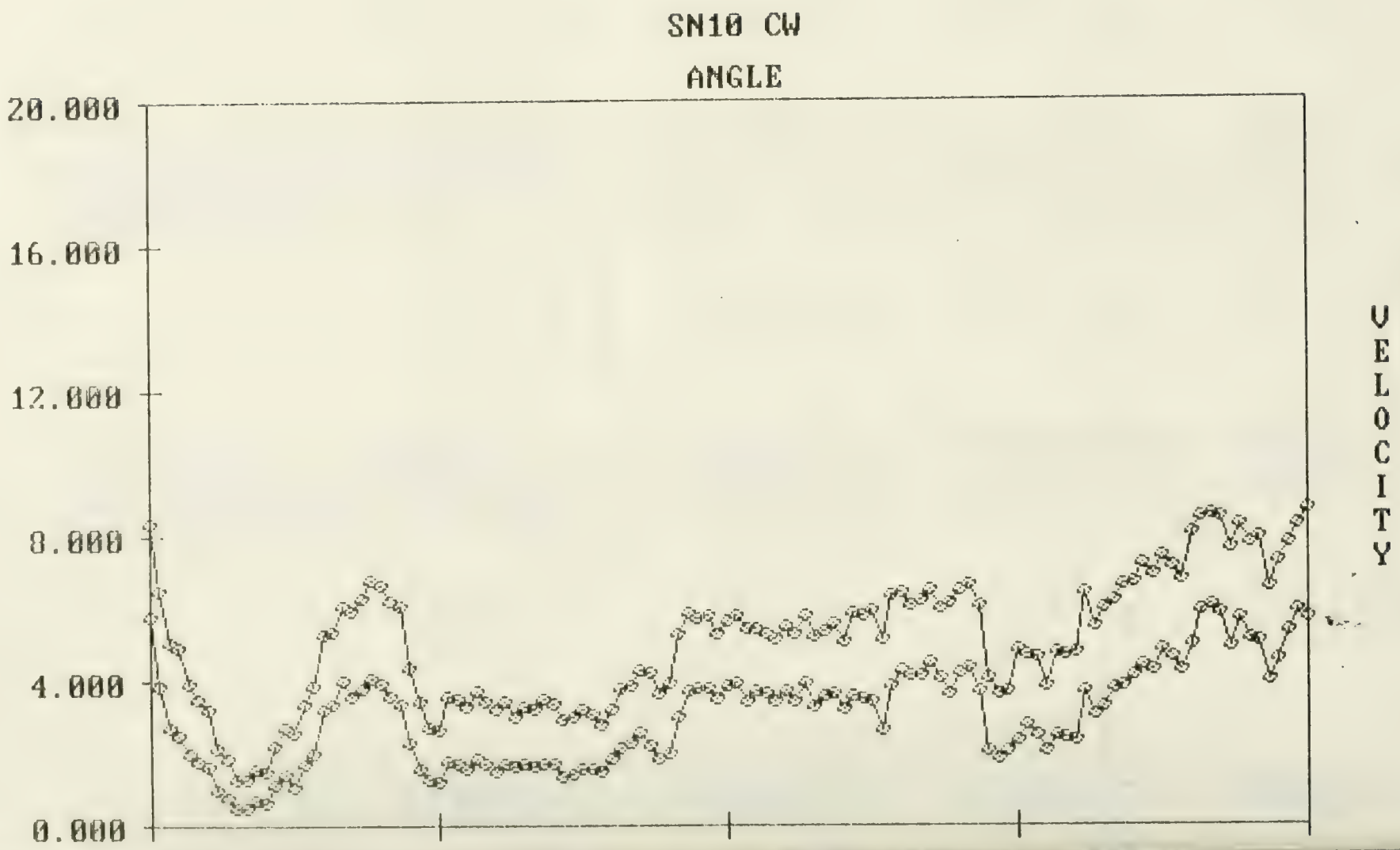
Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.365	5.780	5.440	4.685	5.316
20%	9.196	9.297	9.123	8.014	8.901
10%	11.937	11.775	11.654	10.258	11.407
5%	14.592	14.247	14.119	12.339	13.870
1%	20.975	19.920	19.729	16.935	19.536

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	9.346	10.192	9.502	8.115	9.275
20%	15.580	16.067	15.595	13.509	15.231
10%	19.852	19.930	19.528	17.025	19.116
5%	23.977	23.700	23.216	20.238	22.861
1%	33.496	32.098	31.322	26.934	31.204

17\sb09


SN10 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.946244	0.982566
1.00	0.851726	0.941576
1.50	0.747950	0.887509
2.00	0.642394	0.826789
2.50	0.540233	0.762636
3.00	0.445580	0.696928
3.50	0.361197	0.631110
4.00	0.288321	0.566401
4.50	0.226932	0.503850
5.00	0.176232	0.444333
5.50	0.135058	0.388547
6.00	0.102139	0.336993
6.50	0.076225	0.289974
7.00	0.056141	0.247613
7.50	0.040821	0.209877
8.00	0.029314	0.176612
8.50	0.020800	0.147571
9.00	0.014592	0.122449
9.50	0.010126	0.100906
10.00	0.006954	0.082585
10.50	0.004729	0.067130
11.00	0.003185	0.054197
11.50	0.002125	0.043458
12.00	0.001404	0.034611
12.50	0.000919	0.027377
13.00	0.000596	0.021508
13.50	0.000382	0.016783
14.00	0.000243	0.013008
14.50	0.000152	0.010014
15.00	0.000094	0.007658
15.50	0.000058	0.005818
16.00	0.000035	0.004391
16.50	0.000021	0.003293
17.00	0.000012	0.002453
17.50	0.000007	0.001816
18.00	0.000004	0.001336
18.50	0.000002	0.000977
19.00	0.000001	0.000709
19.50	0.000001	0.000512
20.00	0.000000	0.000367
20.50	0.000000	0.000262
21.00	0.000000	0.000186
21.50	0.000000	0.000131
22.00	0.000000	0.000091
22.50	0.000000	0.000064
23.00	0.000000	0.000044
23.50	0.000000	0.000030
24.00	0.000000	0.000021
24.50	0.000000	0.000014
25.00	0.000000	0.000009

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.702	3.215	2.758	2.272	2.713
20%	4.670	5.449	4.923	3.962	4.766
10%	5.896	6.796	6.263	5.018	6.041
5%	6.988	7.945	7.446	5.967	7.200
1%	9.267	10.251	9.874	7.899	9.520

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.521	5.390	4.599	3.790	4.532
20%	7.492	8.733	7.903	6.371	7.648
10%	9.281	10.676	9.874	7.918	9.525
5%	10.849	12.343	11.601	9.289	11.195
1%	13.993	15.566	15.037	12.005	14.503

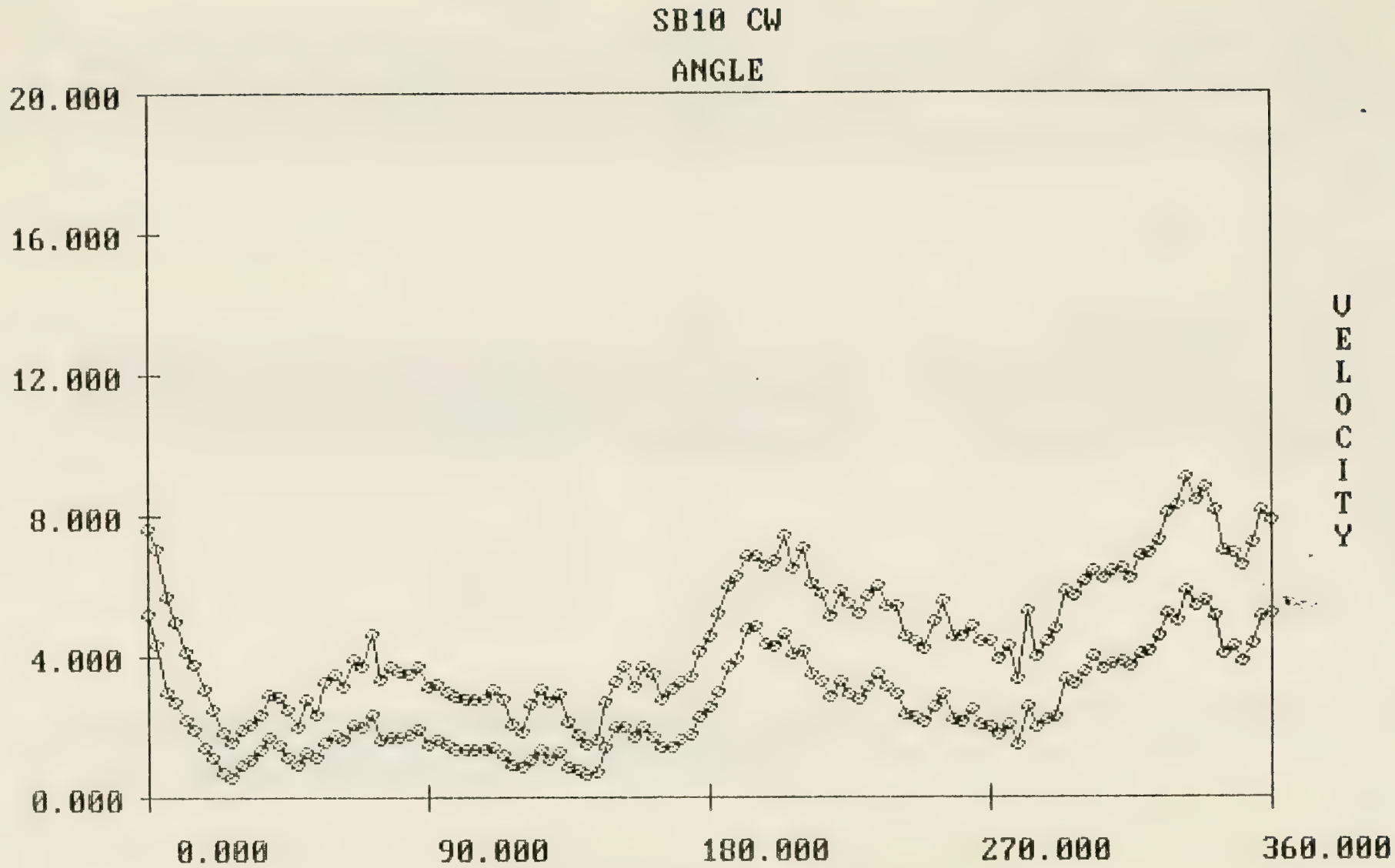
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.043	7.192	6.169	5.081	6.068
20%	10.446	12.188	11.012	8.862	10.660
10%	13.189	15.203	14.011	11.225	13.514
5%	15.631	17.772	16.656	13.347	16.107
1%	20.730	22.930	22.088	17.670	21.295

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.112	12.056	10.289	8.479	10.139
20%	16.760	19.536	17.679	14.252	17.109
10%	20.760	23.882	22.087	17.711	21.306
5%	24.269	27.610	25.951	20.779	25.043
1%	31.302	34.819	33.636	26.855	32.442

\nb17\sn10


SB10 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.934154	0.980196
1.00	0.811160	0.933229
1.50	0.682173	0.870676
2.00	0.561244	0.801106
2.50	0.452500	0.729686
3.00	0.357950	0.659045
3.50	0.278394	0.590454
4.00	0.213312	0.524638
4.50	0.161231	0.462159
5.00	0.120275	0.403529
5.50	0.088559	0.349202
6.00	0.064364	0.299529
6.50	0.046191	0.254722
7.00	0.032750	0.214831
7.50	0.022960	0.179758
8.00	0.015928	0.149281
8.50	0.010943	0.123082
9.00	0.007449	0.100787
9.50	0.005025	0.081989
10.00	0.003359	0.066279
10.50	0.002224	0.053255
11.00	0.001457	0.042542
11.50	0.000945	0.033793
12.00	0.000605	0.026698
12.50	0.000383	0.020982
13.00	0.000240	0.016408
13.50	0.000148	0.012768
14.00	0.000090	0.009889
14.50	0.000054	0.007625
15.00	0.000032	0.005853
15.50	0.000019	0.004473
16.00	0.000011	0.003404
16.50	0.000006	0.002580
17.00	0.000003	0.001947
17.50	0.000002	0.001463
18.00	0.000001	0.001094
18.50	0.000001	0.000815
19.00	0.000000	0.000604
19.50	0.000000	0.000446
20.00	0.000000	0.000327
20.50	0.000000	0.000239
21.00	0.000000	0.000174
21.50	0.000000	0.000125
22.00	0.000000	0.000090
22.50	0.000000	0.000064
23.00	0.000000	0.000046
23.50	0.000000	0.000032
24.00	0.000000	0.000023
24.50	0.000000	0.000016
25.00	0.000000	0.000011

\nb17\sb10

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.252	2.754	2.327	1.892	2.282
20%	4.021	4.790	4.312	3.369	4.128
10%	5.166	6.027	5.538	4.308	5.320
5%	6.202	7.123	6.658	5.165	6.395
1%	8.395	9.333	8.932	6.975	8.635

Vgust (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.148	5.053	4.258	3.496	4.197
20%	7.044	8.259	7.491	5.958	7.211
10%	8.783	10.131	9.401	7.421	9.021
5%	10.328	11.772	11.072	8.726	10.652
1%	13.552	15.053	14.465	11.420	13.981

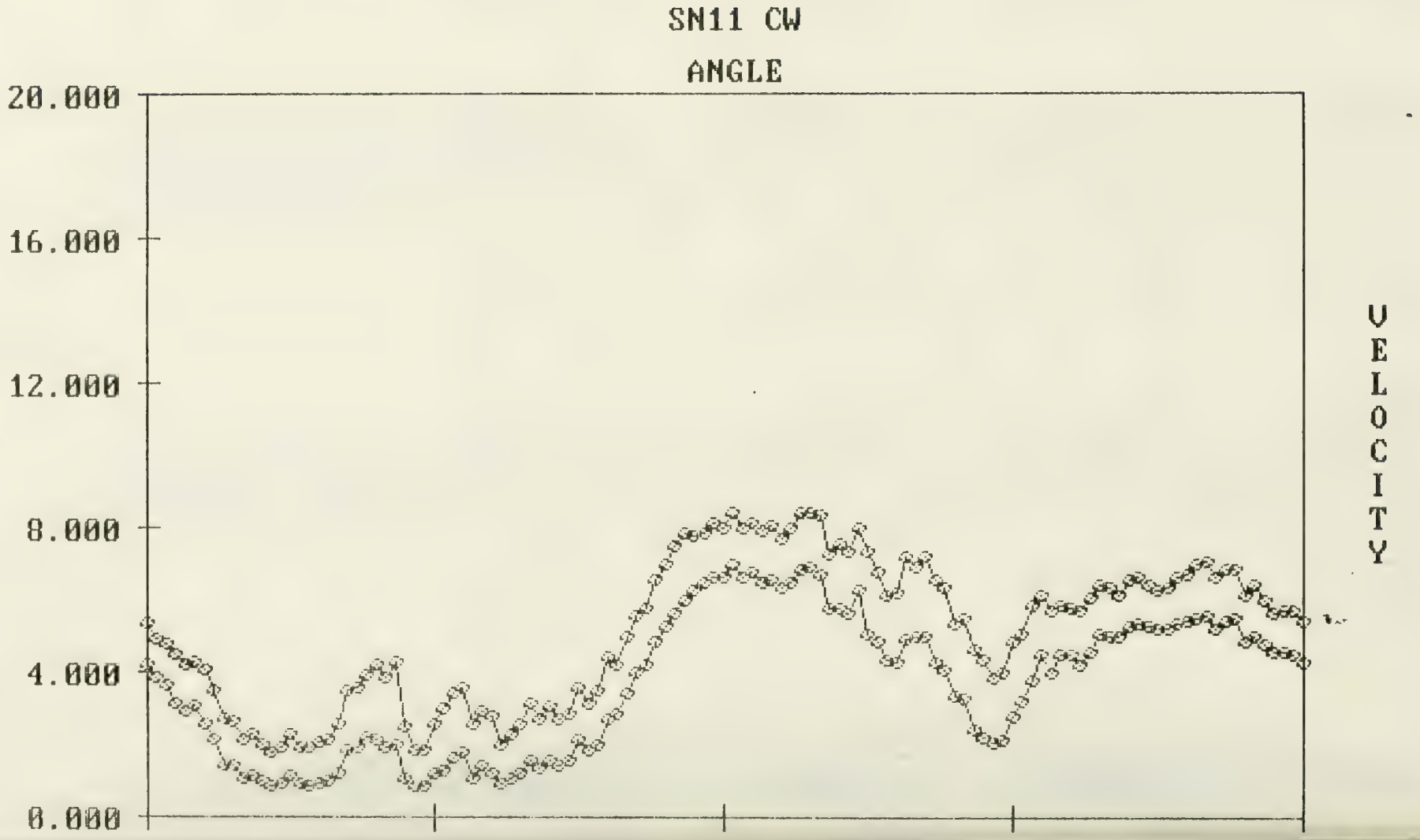
Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.037	6.162	5.205	4.232	5.104
20%	8.996	10.715	9.645	7.535	9.234
10%	11.555	13.482	12.389	9.638	11.900
5%	13.873	15.934	14.894	11.553	14.306
1%	18.780	20.876	19.981	15.604	19.316

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	9.280	11.302	9.525	7.820	9.389
20%	15.756	18.474	16.757	13.327	16.132
10%	19.647	22.663	21.029	16.600	20.179
5%	23.104	26.334	24.768	19.519	23.828
1%	30.315	33.673	32.357	25.545	31.274

17\sb10


SN11 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.951379	0.983467
1.00	0.863497	0.941891
1.50	0.781072	0.885918
2.00	0.702886	0.824374
2.50	0.625428	0.761878
3.00	0.549323	0.699817
3.50	0.476096	0.638375
4.00	0.407151	0.577749
4.50	0.343544	0.518428
5.00	0.285975	0.461077
5.50	0.234833	0.406376
6.00	0.190231	0.354926
6.50	0.152039	0.307198
7.00	0.119924	0.263515
7.50	0.093391	0.224050
8.00	0.071841	0.188843
8.50	0.054625	0.157813
9.00	0.041084	0.130784
9.50	0.030590	0.107507
10.00	0.022571	0.087680
10.50	0.016521	0.070970
11.00	0.012011	0.057030
11.50	0.008684	0.045515
12.00	0.006253	0.036092
12.50	0.004490	0.028449
13.00	0.003220	0.022302
13.50	0.002308	0.017396
14.00	0.001656	0.013510
14.50	0.001190	0.010452
15.00	0.000857	0.008060
15.50	0.000618	0.006198
16.00	0.000447	0.004756
16.50	0.000324	0.003643
17.00	0.000235	0.002787
17.50	0.000170	0.002130
18.00	0.000124	0.001627
18.50	0.000090	0.001242
19.00	0.000065	0.000948
19.50	0.000047	0.000723
20.00	0.000034	0.000551
20.50	0.000024	0.000420
21.00	0.000018	0.000320
21.50	0.000013	0.000244
22.00	0.000009	0.000185
22.50	0.000006	0.000141
23.00	0.000005	0.000107
23.50	0.000003	0.000081
24.00	0.000002	0.000061
24.50	0.000002	0.000047
25.00	0.000001	0.000035

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.254	4.014	3.375	2.808	3.337
20%	5.753	6.676	6.102	4.962	5.890
10%	7.191	8.179	7.653	6.227	7.375
5%	8.439	9.470	8.969	7.321	8.671
1%	11.026	12.181	11.558	9.524	11.302

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.592	5.511	4.684	3.967	4.661
20%	7.691	8.770	8.086	6.711	7.842
10%	9.482	10.622	10.016	8.306	9.689
5%	11.069	12.248	11.678	9.702	11.305
1%	14.352	15.666	14.911	12.511	14.595

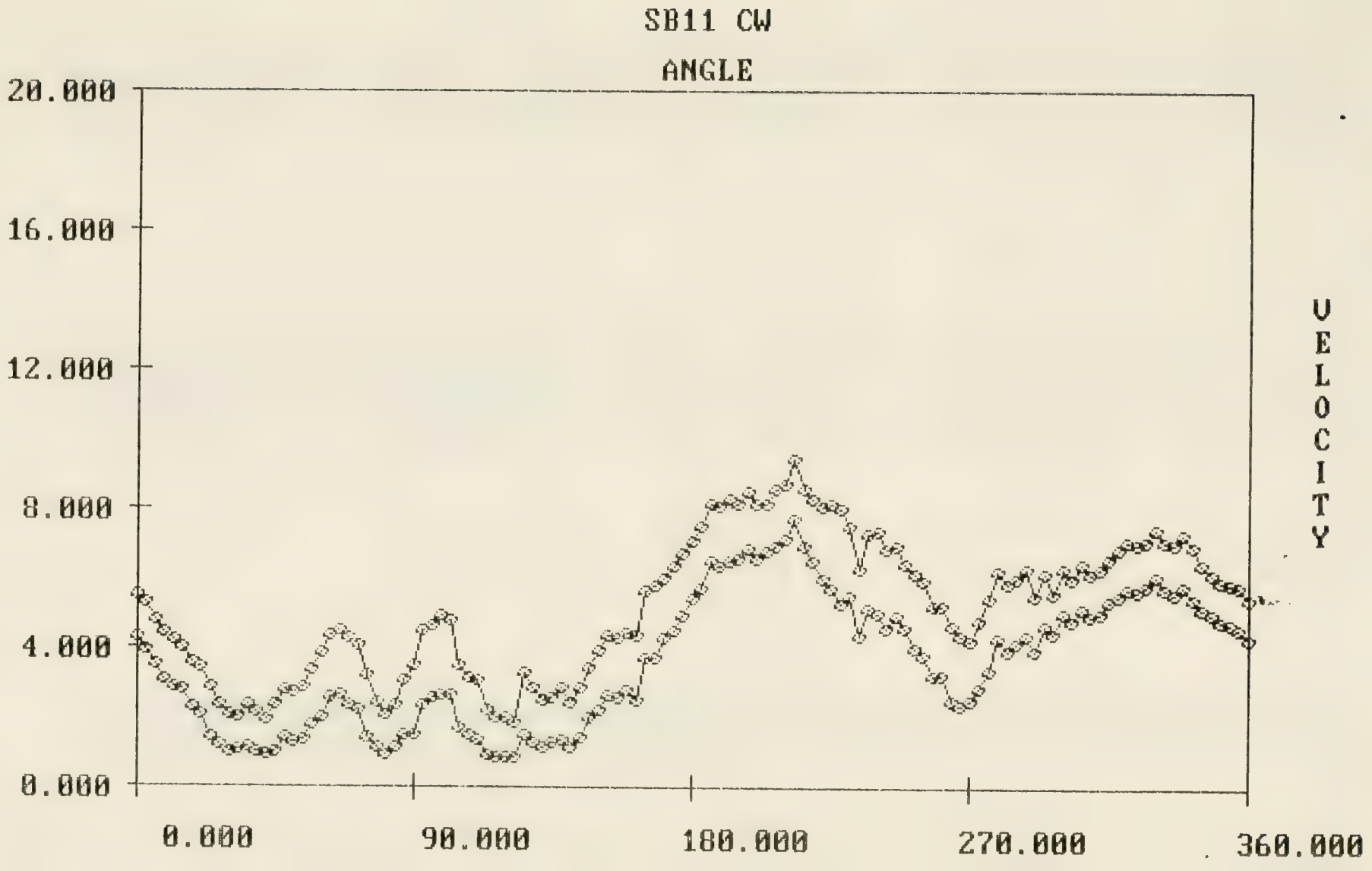
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.280	8.978	7.550	6.281	7.464
20%	12.869	14.934	13.649	11.100	13.177
10%	16.086	18.296	17.120	13.929	16.498
5%	18.877	21.184	20.063	16.377	19.396
1%	24.665	27.249	25.855	21.305	25.282

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.273	12.327	10.477	8.873	10.426
20%	17.204	19.618	18.088	15.013	17.541
10%	21.211	23.760	22.404	18.580	21.674
5%	24.761	27.397	26.122	21.703	25.289
1%	32.105	35.043	33.355	27.987	32.647

sn11


SB11 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.955158	0.984303
1.00	0.871685	0.945657
1.50	0.788681	0.892955
2.00	0.709975	0.833484
2.50	0.632797	0.771762
3.00	0.557092	0.709911
3.50	0.484162	0.648754
4.00	0.415383	0.588705
4.50	0.351842	0.530180
5.00	0.294275	0.473678
5.50	0.243086	0.419732
6.00	0.198376	0.368847
6.50	0.159996	0.321442
7.00	0.127594	0.277826
7.50	0.100672	0.238187
8.00	0.078638	0.202590
8.50	0.060861	0.170993
9.00	0.046708	0.143256
9.50	0.035579	0.119168
10.00	0.026925	0.098461
10.50	0.020264	0.080833
11.00	0.015183	0.065965
11.50	0.011338	0.053532
12.00	0.008447	0.043221
12.50	0.006284	0.034735
13.00	0.004672	0.027799
13.50	0.003475	0.022168
14.00	0.002586	0.017622
14.50	0.001927	0.013971
15.00	0.001437	0.011052
15.50	0.001074	0.008727
16.00	0.000803	0.006882
16.50	0.000601	0.005421
17.00	0.000450	0.004267
17.50	0.000337	0.003356
18.00	0.000252	0.002639
18.50	0.000188	0.002074
19.00	0.000141	0.001629
19.50	0.000105	0.001279
20.00	0.000078	0.001004
20.50	0.000058	0.000788
21.00	0.000043	0.000617
21.50	0.000032	0.000484
22.00	0.000024	0.000378
22.50	0.000017	0.000296
23.00	0.000013	0.000231
23.50	0.000009	0.000180
24.00	0.000007	0.000140
24.50	0.000005	0.000109
25.00	0.000004	0.000085

sb11

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.316	4.050	3.421	2.870	3.391
20%	5.870	6.724	6.195	5.084	5.982
10%	7.385	8.269	7.791	6.405	7.515
5%	8.747	9.632	9.171	7.580	8.884
1%	11.649	12.575	11.926	10.042	11.731

Vgust (m/s)

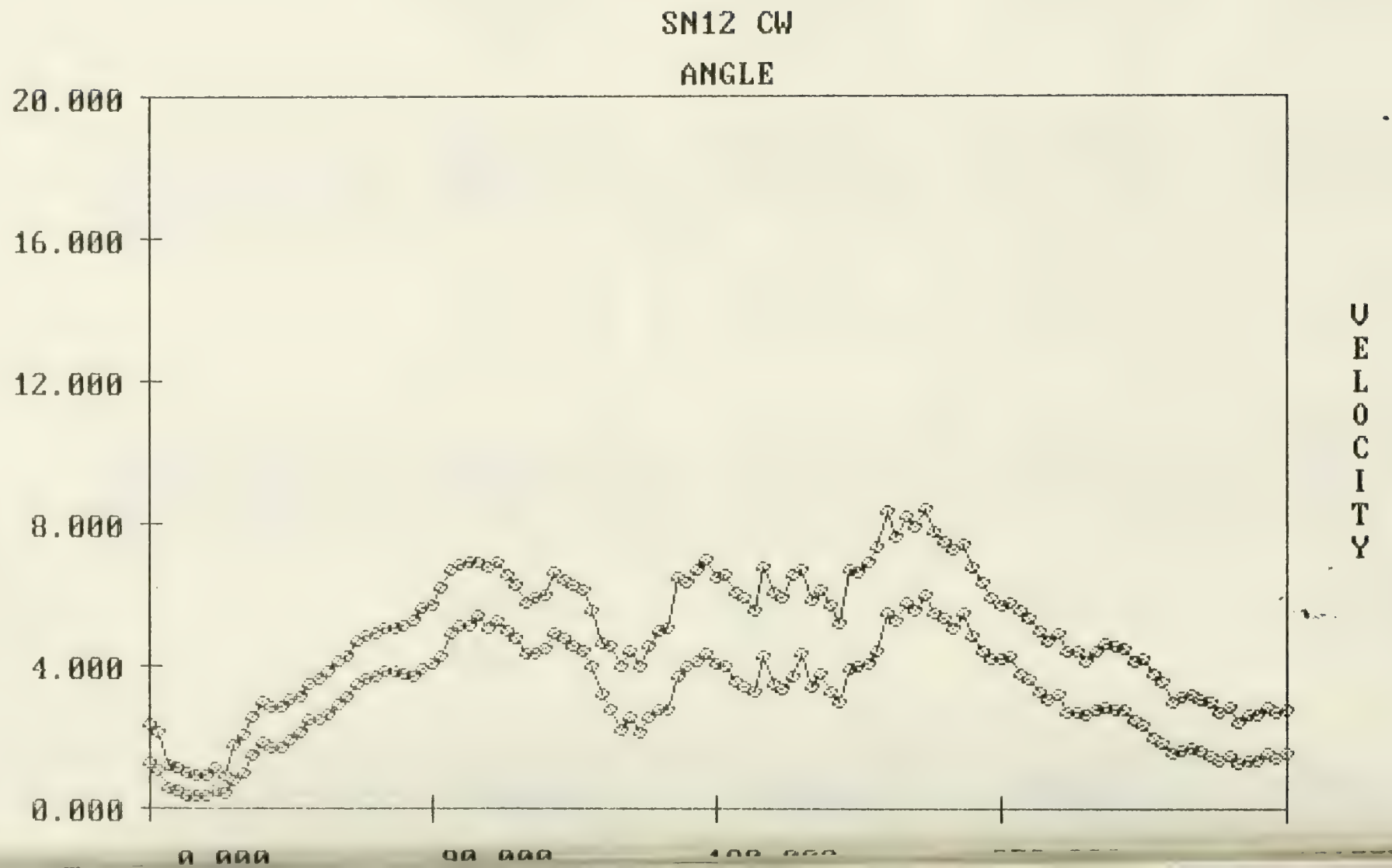
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.710	5.604	4.787	4.071	4.767
20%	7.916	8.929	8.288	6.922	8.041
10%	9.819	10.847	10.296	8.610	9.963
5%	11.517	12.547	12.019	10.110	11.671
1%	15.144	16.297	15.466	13.214	15.226

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.418	9.060	7.652	6.421	7.586
20%	13.131	15.042	13.858	11.372	13.381
10%	16.519	18.497	17.428	14.329	16.811
5%	19.567	21.545	20.515	16.957	19.872
1%	26.057	28.130	26.677	22.464	26.242

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.535	12.535	10.709	9.107	10.664
20%	17.707	19.974	18.539	15.483	17.987
10%	21.966	24.264	23.032	19.260	22.286
5%	25.762	28.067	26.887	22.615	26.108
1%	33.877	36.456	34.598	29.559	34.060


SN12 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.927623	0.973920
1.00	0.822887	0.917518
1.50	0.704577	0.850634
2.00	0.588703	0.777863
2.50	0.484702	0.701302
3.00	0.394582	0.624501
3.50	0.317958	0.550593
4.00	0.253958	0.481535
4.50	0.201448	0.418294
5.00	0.159024	0.361207
5.50	0.125130	0.310244
6.00	0.098230	0.265175
6.50	0.076947	0.225657
7.00	0.060127	0.191276
7.50	0.046842	0.161577
8.00	0.036363	0.136083
8.50	0.028116	0.114317
9.00	0.021648	0.095817
9.50	0.016595	0.080148
10.00	0.012668	0.066915
10.50	0.009630	0.055763
11.00	0.007293	0.046381
11.50	0.005504	0.038503
12.00	0.004141	0.031897
12.50	0.003108	0.026366
13.00	0.002329	0.021746
13.50	0.001742	0.017893
14.00	0.001303	0.014687
14.50	0.000975	0.012027
15.00	0.000730	0.009825
15.50	0.000547	0.008007
16.00	0.000411	0.006511
16.50	0.000309	0.005282
17.00	0.000234	0.004277
17.50	0.000177	0.003456
18.00	0.000134	0.002788
18.50	0.000102	0.002245
19.00	0.000078	0.001805
19.50	0.000059	0.001449
20.00	0.000045	0.001162
20.50	0.000035	0.000931
21.00	0.000027	0.000745
21.50	0.000020	0.000596
22.00	0.000016	0.000477
22.50	0.000012	0.000381
23.00	0.000009	0.000305
23.50	0.000007	0.000243
24.00	0.000005	0.000194
24.50	0.000004	0.000155
25.00	0.000003	0.000124

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.415	2.668	2.415	2.230	2.426
20%	4.628	4.785	4.526	4.148	4.517
10%	6.253	6.211	5.968	5.454	5.967
5%	7.820	7.622	7.380	6.689	7.381
1%	11.210	10.749	10.428	9.164	10.439

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.853	4.286	3.864	3.484	3.866
20%	6.992	7.308	6.905	6.247	6.873
10%	9.221	9.284	8.926	8.077	8.887
5%	11.329	11.223	10.843	9.773	10.807
1%	15.777	15.584	14.945	13.189	14.960

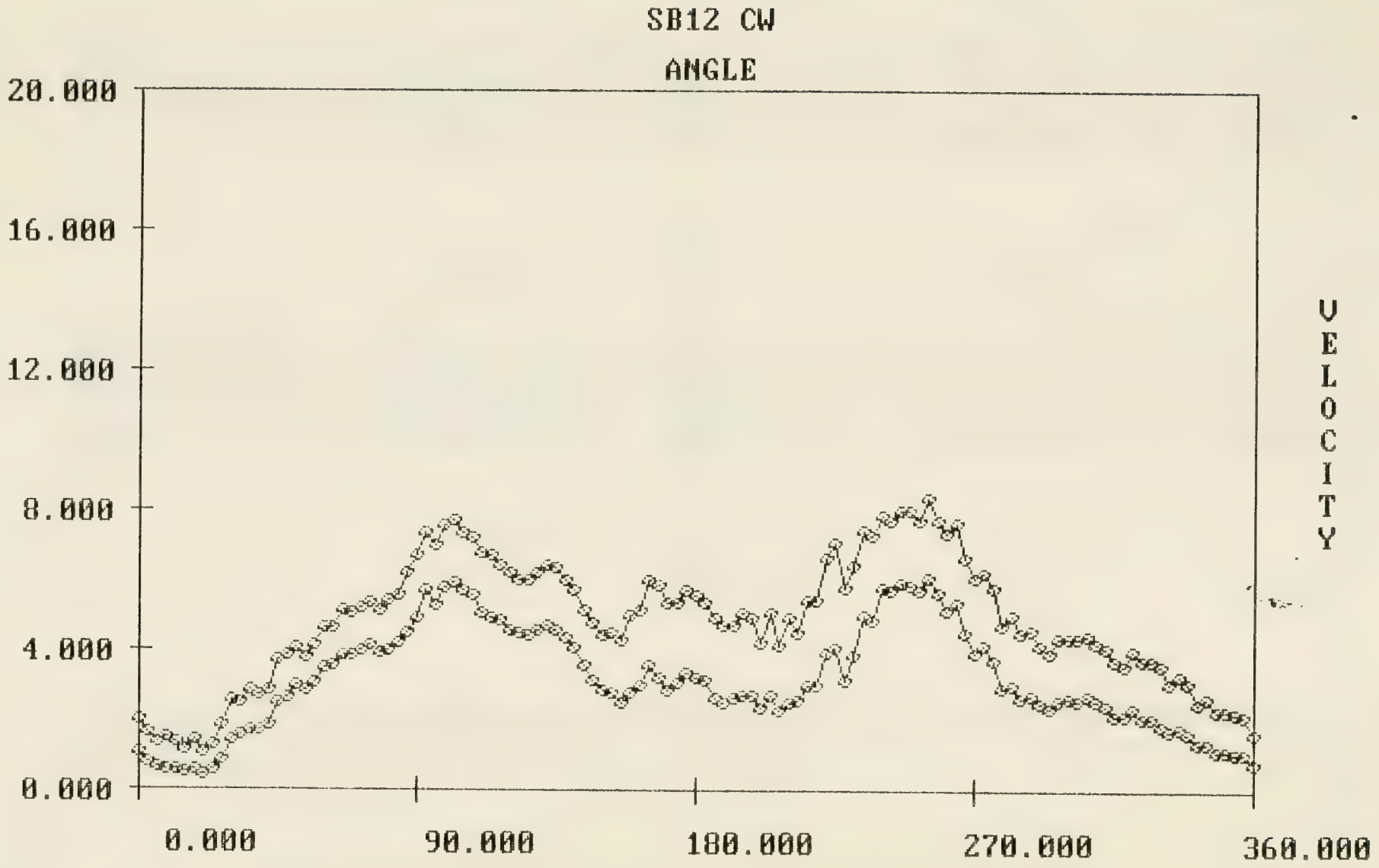
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.403	5.968	5.402	4.989	5.428
20%	10.353	10.705	10.123	9.278	10.104
10%	13.987	13.893	13.350	12.200	13.348
5%	17.494	17.051	16.510	14.963	16.511
1%	25.076	24.045	23.327	20.499	23.352

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.619	9.587	8.645	7.793	8.649
20%	15.640	16.348	15.445	13.973	15.375
10%	20.626	20.767	19.968	18.067	19.880
5%	25.342	25.104	24.254	21.861	24.175
1%	35.293	34.860	33.430	29.504	33.465

sn12


SB12 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.928902	0.976244
1.00	0.815290	0.919988
1.50	0.694572	0.848847
2.00	0.575183	0.772307
2.50	0.465365	0.694093
3.00	0.370219	0.616541
3.50	0.291836	0.541753
4.00	0.229610	0.471439
4.50	0.181259	0.406799
5.00	0.143930	0.348542
5.50	0.114954	0.296945
6.00	0.092183	0.251919
6.50	0.074036	0.213097
7.00	0.059406	0.179925
7.50	0.047529	0.151759
8.00	0.037863	0.127933
8.50	0.030007	0.107811
9.00	0.023648	0.090820
9.50	0.018529	0.076460
10.00	0.014434	0.064309
10.50	0.011181	0.054015
11.00	0.008614	0.045288
11.50	0.006604	0.037888
12.00	0.005039	0.031619
12.50	0.003828	0.026314
13.00	0.002898	0.021836
13.50	0.002188	0.018064
14.00	0.001647	0.014898
14.50	0.001238	0.012249
15.00	0.000930	0.010040
15.50	0.000698	0.008205
16.00	0.000524	0.006687
16.50	0.000394	0.005435
17.00	0.000296	0.004406
17.50	0.000223	0.003563
18.00	0.000169	0.002876
18.50	0.000128	0.002316
19.00	0.000097	0.001862
19.50	0.000073	0.001495
20.00	0.000056	0.001199
20.50	0.000043	0.000961
21.00	0.000033	0.000769
21.50	0.000025	0.000616
22.00	0.000019	0.000493
22.50	0.000014	0.000394
23.00	0.000011	0.000316
23.50	0.000008	0.000253
24.00	0.000006	0.000203
24.50	0.000005	0.000163
25.00	0.000004	0.000131

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.327	2.592	2.348	2.111	2.342
20%	4.398	4.501	4.312	3.955	4.306
10%	6.156	5.978	5.801	5.382	5.828
5%	7.905	7.592	7.367	6.742	7.396
1%	11.508	11.000	10.766	9.383	10.730

Vguat (m/s)

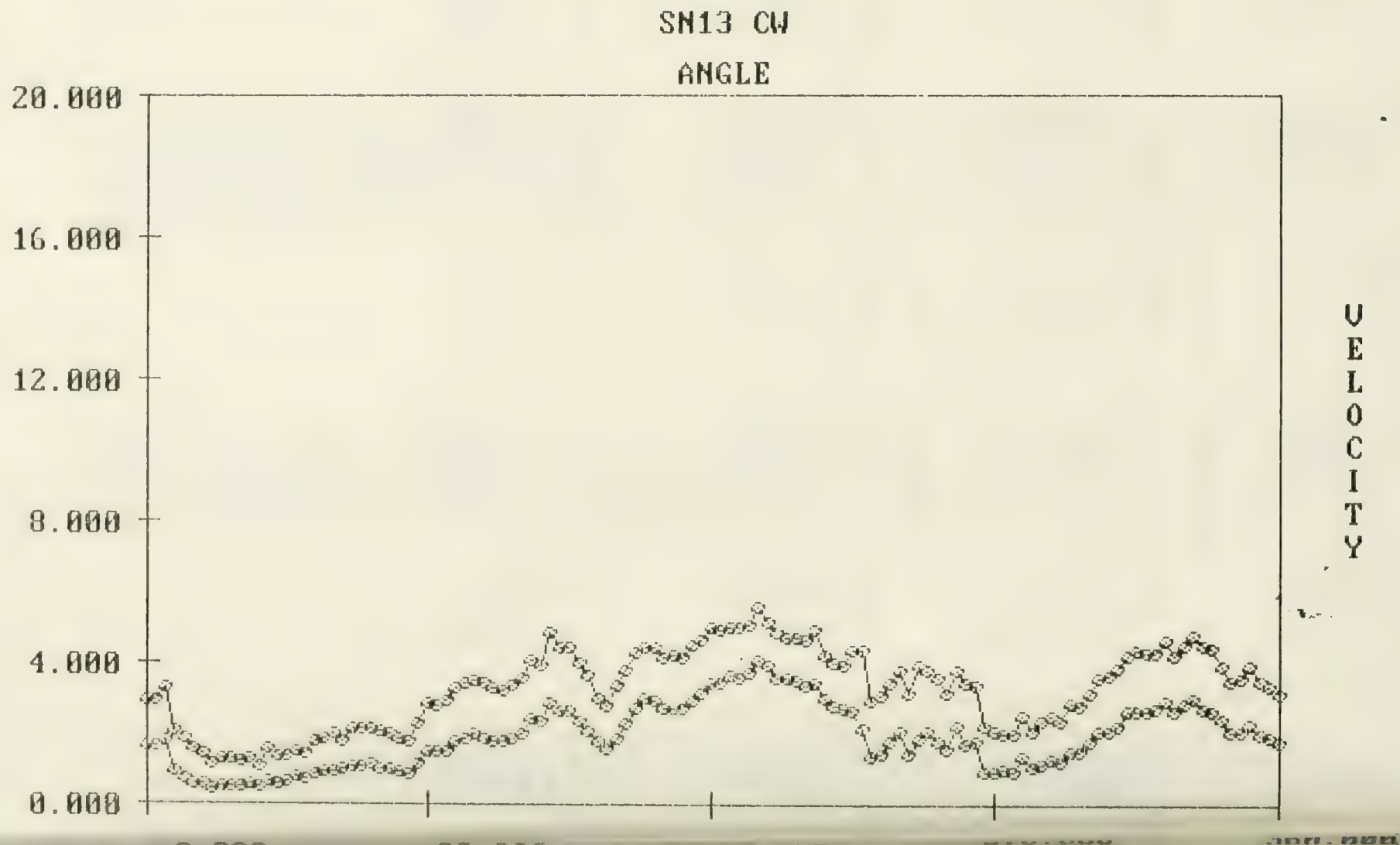
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.779	4.236	3.809	3.391	3.797
20%	6.799	7.137	6.719	6.069	6.697
10%	9.059	9.126	8.741	7.946	8.730
5%	11.275	11.146	10.766	9.700	10.730
1%	15.860	15.519	15.181	13.133	15.011

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.205	5.798	5.253	4.722	5.240
20%	9.839	10.068	9.645	8.847	9.633
10%	13.771	13.373	12.977	12.040	13.038
5%	17.683	16.984	16.479	15.082	16.544
1%	25.742	24.606	24.083	20.989	24.002

Vguat (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.453	9.476	8.521	7.586	8.493
20%	15.208	15.964	15.029	13.577	14.982
10%	20.264	20.415	19.552	17.774	19.528
5%	25.222	24.934	24.082	21.699	24.002
1%	35.478	34.715	33.958	29.378	33.579


SN13 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.875228	0.962106
1.00	0.674615	0.870475
1.50	0.490340	0.756476
2.00	0.340468	0.640009
2.50	0.228466	0.529323
3.00	0.149108	0.428276
3.50	0.094935	0.339327
4.00	0.059096	0.263663
4.50	0.036062	0.201198
5.00	0.021653	0.150932
5.50	0.012855	0.111384
6.00	0.007587	0.080905
6.50	0.004475	0.057875
7.00	0.002648	0.040804
7.50	0.001575	0.028383
8.00	0.000942	0.019505
8.50	0.000565	0.013267
9.00	0.000339	0.008951
9.50	0.000203	0.006007
10.00	0.000122	0.004023
10.50	0.000073	0.002697
11.00	0.000043	0.001817
11.50	0.000026	0.001234
12.00	0.000015	0.000848
12.50	0.000009	0.000589
13.00	0.000005	0.000416
13.50	0.000003	0.000297
14.00	0.000002	0.000215
14.50	0.000001	0.000157
15.00	0.000001	0.000116
15.50	0.000000	0.000086
16.00	0.000000	0.000065
16.50	0.000000	0.000049
17.00	0.000000	0.000037
17.50	0.000000	0.000028
18.00	0.000000	0.000021
18.50	0.000000	0.000016
19.00	0.000000	0.000012
19.50	0.000000	0.000009
20.00	0.000000	0.000007
20.50	0.000000	0.000005
21.00	0.000000	0.000004
21.50	0.000000	0.000003
22.00	0.000000	0.000002
22.50	0.000000	0.000002
23.00	0.000000	0.000001
23.50	0.000000	0.000001
24.00	0.000000	0.000001
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.477	1.698	1.522	1.257	1.474
20%	2.723	2.944	2.779	2.256	2.679
10%	3.510	3.765	3.577	2.900	3.453
5%	4.290	4.484	4.323	3.488	4.197
1%	5.943	6.130	5.827	4.829	5.771

Vguat (m/s)

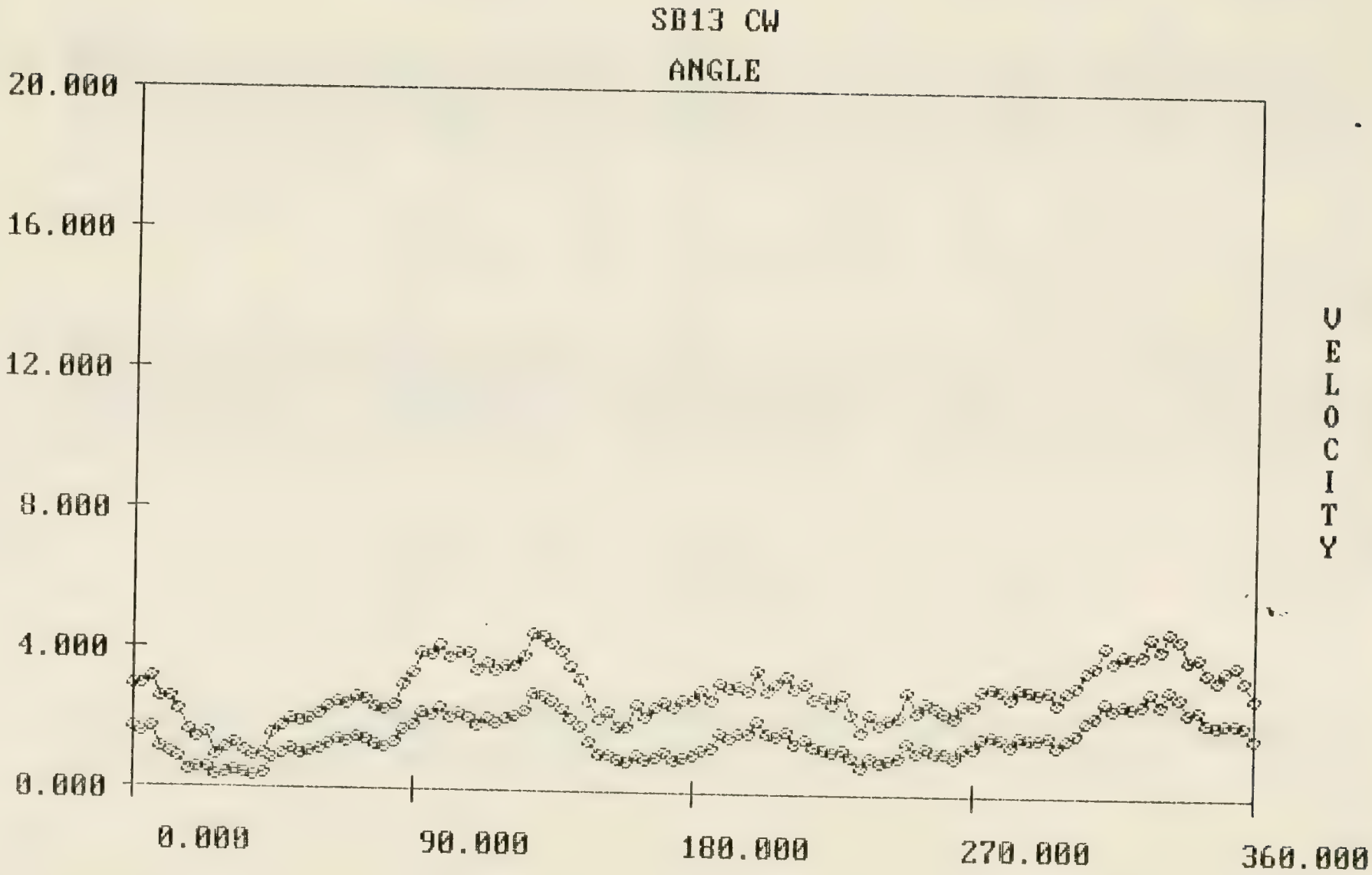
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.645	3.037	2.717	2.245	2.645
20%	4.565	4.989	4.660	3.828	4.512
10%	5.765	6.197	5.848	4.799	5.687
5%	6.840	7.256	6.890	5.653	6.731
1%	9.172	9.403	8.946	7.372	8.878

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.304	3.799	3.405	2.811	3.297
20%	6.090	6.585	6.216	5.047	5.994
10%	7.851	8.423	8.001	6.488	7.725
5%	9.595	10.030	9.669	7.802	9.389
1%	13.295	13.712	13.034	10.801	12.909

Vguat (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.916	6.794	6.077	5.022	5.917
20%	10.211	11.160	10.425	8.562	10.093
10%	12.895	13.863	13.081	10.736	12.721
5%	15.301	16.232	15.413	12.645	15.056
1%	20.518	21.034	20.011	16.490	19.861


SB13 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.855782	0.956085
1.00	0.623392	0.854144
1.50	0.410195	0.726837
2.00	0.253072	0.594109
2.50	0.150067	0.468545
3.00	0.086906	0.357881
3.50	0.049552	0.265630
4.00	0.027817	0.192192
4.50	0.015301	0.135980
5.00	0.008210	0.094372
5.50	0.004300	0.064432
6.00	0.002216	0.043394
6.50	0.001141	0.028900
7.00	0.000599	0.019075
7.50	0.000326	0.012507
8.00	0.000186	0.008166
8.50	0.000111	0.005327
9.00	0.000068	0.003484
9.50	0.000043	0.002296
10.00	0.000027	0.001532
10.50	0.000017	0.001041
11.00	0.000011	0.000721
11.50	0.000007	0.000511
12.00	0.000004	0.000370
12.50	0.000002	0.000272
13.00	0.000001	0.000203
13.50	0.000001	0.000153
14.00	0.000001	0.000116
14.50	0.000000	0.000088
15.00	0.000000	0.000067
15.50	0.000000	0.000051
16.00	0.000000	0.000038
16.50	0.000000	0.000029
17.00	0.000000	0.000022
17.50	0.000000	0.000016
18.00	0.000000	0.000012
18.50	0.000000	0.000009
19.00	0.000000	0.000007
19.50	0.000000	0.000005
20.00	0.000000	0.000004
20.50	0.000000	0.000003
21.00	0.000000	0.000002
21.50	0.000000	0.000001
22.00	0.000000	0.000001
22.50	0.000000	0.000001
23.00	0.000000	0.000001
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

tability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.278	1.559	1.342	1.036	1.289
20%	2.239	2.605	2.360	1.782	2.258
10%	2.888	3.279	3.005	2.259	2.896
5%	3.515	3.889	3.658	2.714	3.494
1%	5.028	5.166	4.968	3.756	4.874

Vgust (m/s)

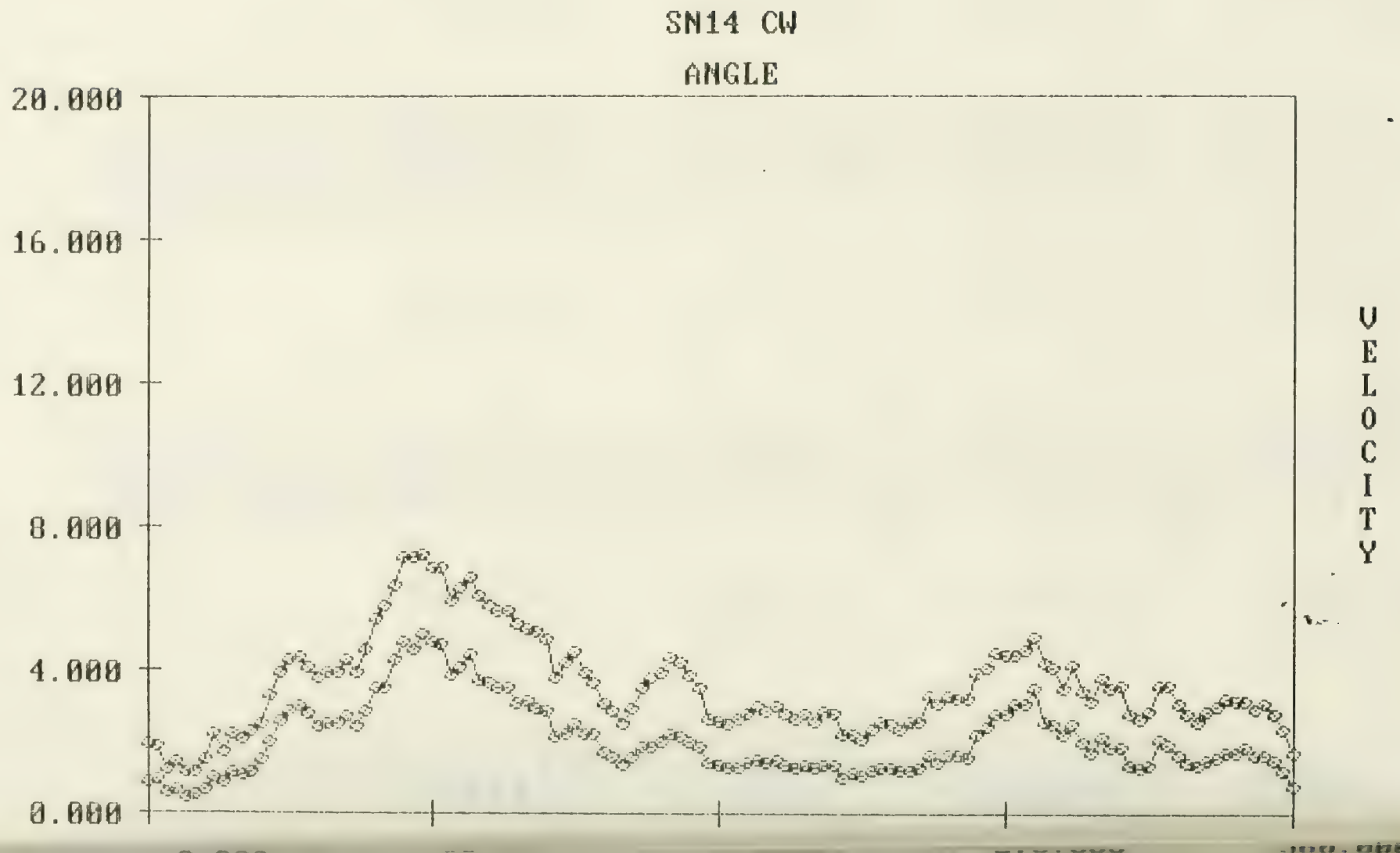
tability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.358	2.838	2.458	1.952	2.375
20%	3.926	4.498	4.116	3.196	3.947
10%	4.920	5.483	5.137	3.938	4.932
5%	5.873	6.371	6.043	4.625	5.843
1%	8.194	8.155	7.925	6.054	7.789

Vmean (mph)

tability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.858	3.487	3.001	2.319	2.884
20%	5.010	5.827	5.279	3.986	5.050
10%	6.460	7.336	6.722	5.054	6.479
5%	7.862	8.699	8.182	6.071	7.816
1%	11.246	11.557	11.112	8.401	10.902

Vgust (mph)

tability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.275	6.348	5.499	4.366	5.312
20%	8.782	10.062	9.207	7.150	8.829
10%	11.007	12.265	11.492	8.810	11.033
5%	13.137	14.251	13.518	10.345	13.070
1%	18.330	18.241	17.729	13.542	17.423


SN14 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.891904	0.966637
1.00	0.686968	0.884163
1.50	0.480420	0.774830
2.00	0.315232	0.655239
2.50	0.200395	0.536570
3.00	0.126159	0.426785
3.50	0.079416	0.330883
4.00	0.050080	0.251008
4.50	0.031627	0.187044
5.00	0.020010	0.137424
5.50	0.012708	0.099888
6.00	0.008127	0.072038
6.50	0.005257	0.051676
7.00	0.003455	0.036954
7.50	0.002316	0.026403
8.00	0.001585	0.018893
8.50	0.001108	0.013577
9.00	0.000788	0.009828
9.50	0.000569	0.007187
10.00	0.000414	0.005325
10.50	0.000303	0.004008
11.00	0.000222	0.003067
11.50	0.000162	0.002389
12.00	0.000118	0.001892
12.50	0.000086	0.001521
13.00	0.000061	0.001239
13.50	0.000044	0.001019
14.00	0.000031	0.000846
14.50	0.000022	0.000706
15.00	0.000015	0.000591
15.50	0.000010	0.000496
16.00	0.000007	0.000417
16.50	0.000005	0.000350
17.00	0.000003	0.000293
17.50	0.000002	0.000246
18.00	0.000001	0.000205
18.50	0.000001	0.000171
19.00	0.000001	0.000142
19.50	0.000000	0.000118
20.00	0.000000	0.000097
20.50	0.000000	0.000080
21.00	0.000000	0.000066
21.50	0.000000	0.000054
22.00	0.000000	0.000044
22.50	0.000000	0.000036
23.00	0.000000	0.000029
23.50	0.000000	0.000023
24.00	0.000000	0.000019
24.50	0.000000	0.000015
25.00	0.000000	0.000012

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.440	1.707	1.493	1.227	1.453
20%	2.485	2.811	2.627	2.106	2.503
10%	3.307	3.509	3.435	2.737	3.280
5%	4.188	4.214	4.261	3.341	4.002
1%	6.631	5.650	6.029	4.656	5.796

Vgust (m/s)

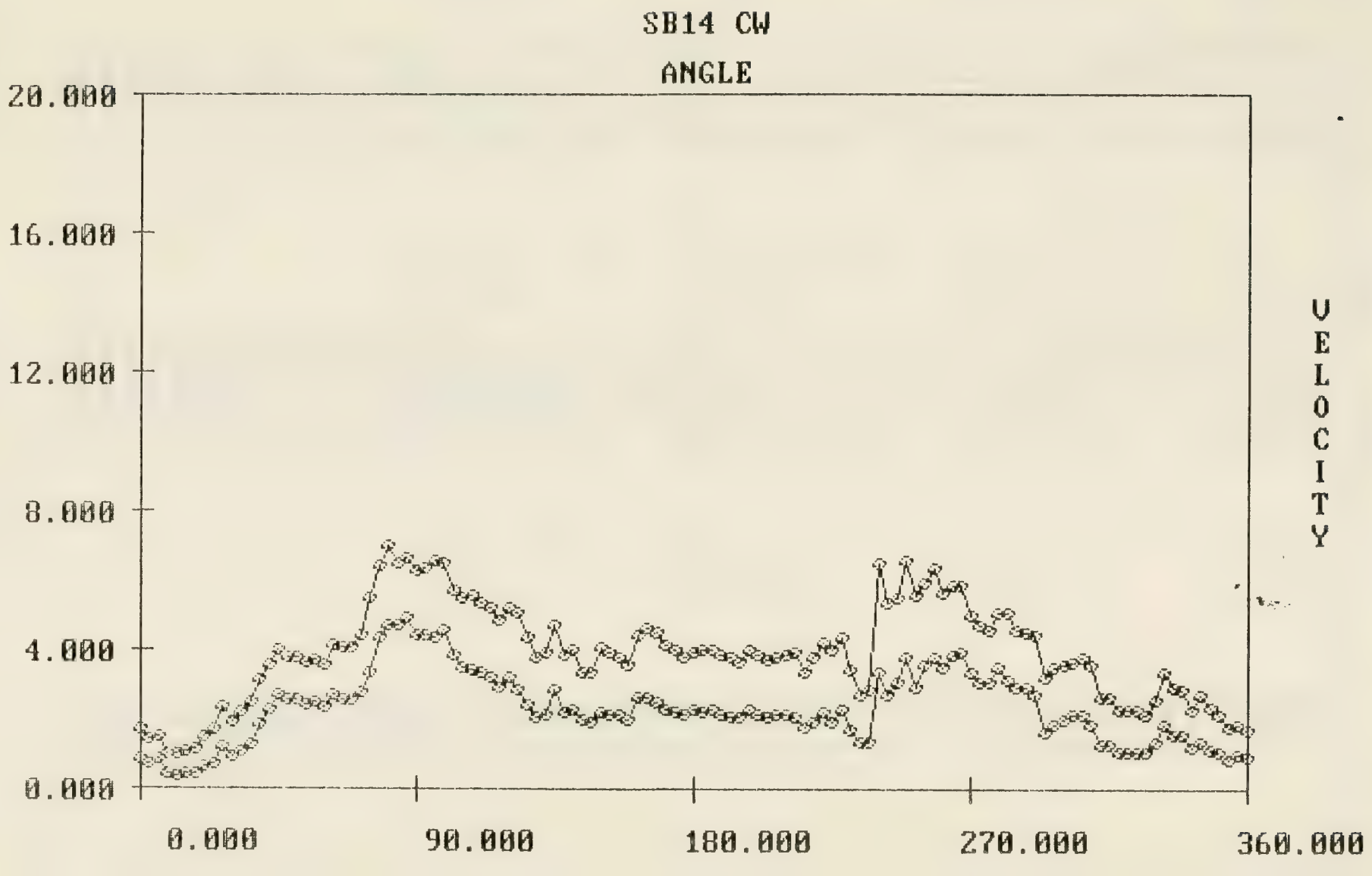
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.648	3.099	2.744	2.249	2.667
20%	4.371	4.890	4.569	3.701	4.399
10%	5.517	5.955	5.772	4.604	5.499
5%	6.746	6.909	6.897	5.438	6.557
1%	10.405	8.827	9.335	7.218	8.977

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.222	3.819	3.341	2.745	3.249
20%	5.560	6.288	5.876	4.711	5.598
10%	7.397	7.849	7.684	6.123	7.337
5%	9.367	9.427	9.531	7.475	8.953
1%	14.833	12.640	13.486	10.415	12.964

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.923	6.933	6.139	5.032	5.965
20%	9.777	10.939	10.220	8.278	9.840
10%	12.341	13.320	12.911	10.299	12.300
5%	15.090	15.455	15.427	12.164	14.667
1%	23.276	19.746	20.883	16.147	20.081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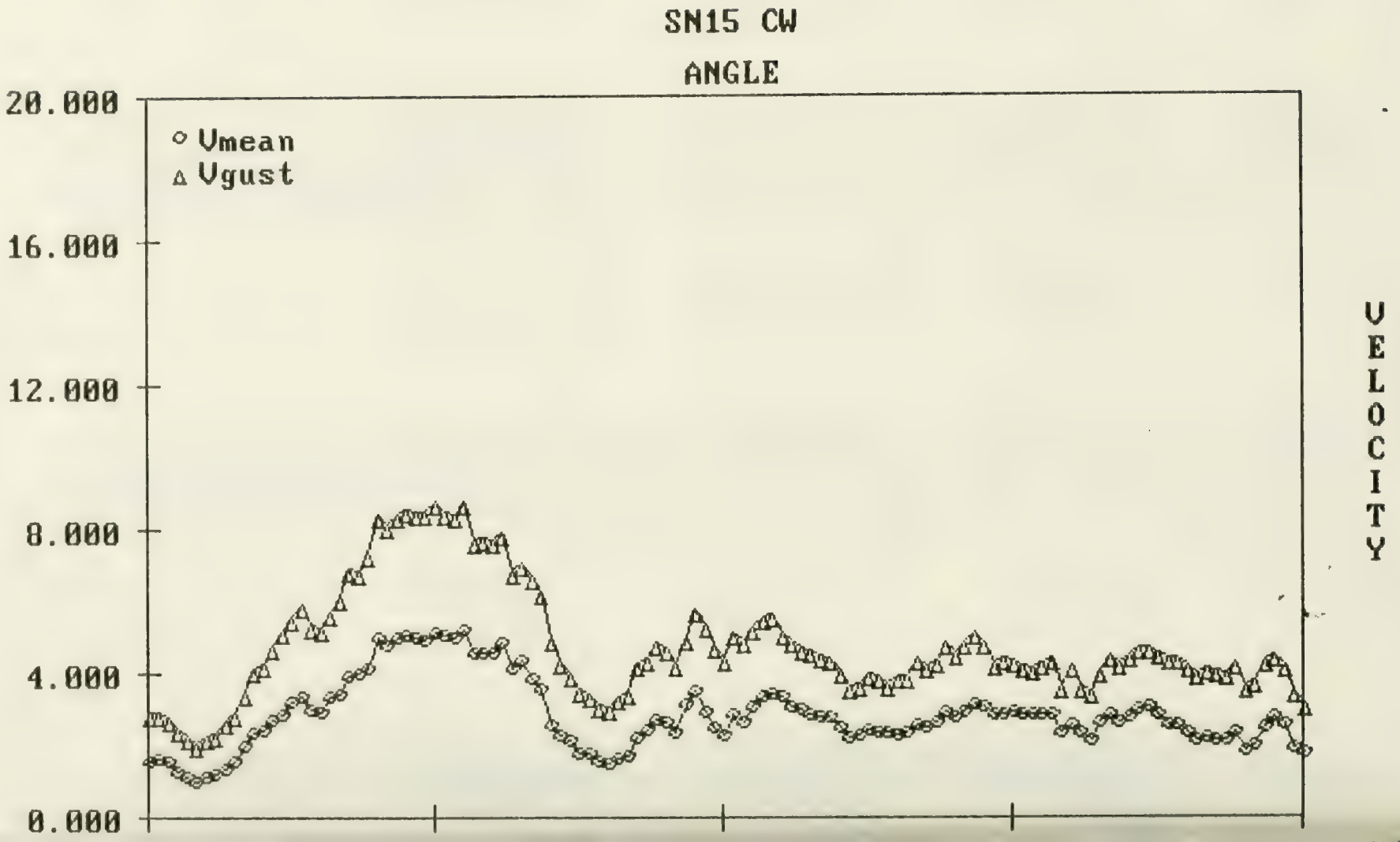
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000


SN15 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
Vmean
Vgust
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.954054	0.983773
1.00	0.843343	0.940255
1.50	0.701724	0.875092
2.00	0.553666	0.794757
2.50	0.415035	0.705584
3.00	0.296111	0.613090
3.50	0.201770	0.521766
4.00	0.131965	0.435117
4.50	0.083368	0.355720
5.00	0.051266	0.285267
5.50	0.030984	0.224605
6.00	0.018628	0.173834
6.50	0.011307	0.132452
7.00	0.007044	0.099543
7.50	0.004571	0.073956
8.00	0.003119	0.054462
8.50	0.002239	0.039876
9.00	0.001680	0.029128
9.50	0.001304	0.021309
10.00	0.001036	0.015675
10.50	0.000834	0.011641
11.00	0.000676	0.008761
11.50	0.000549	0.006701
12.00	0.000446	0.005221
12.50	0.000362	0.004147
13.00	0.000292	0.003357
13.50	0.000235	0.002766
14.00	0.000188	0.002315
14.50	0.000150	0.001965
15.00	0.000119	0.001686
15.50	0.000094	0.001460
16.00	0.000074	0.001272
16.50	0.000058	0.001115
17.00	0.000045	0.000980
17.50	0.000035	0.000864
18.00	0.000027	0.000762
18.50	0.000021	0.000673
19.00	0.000016	0.000595
19.50	0.000012	0.000525
20.00	0.000009	0.000463
20.50	0.000007	0.000408
21.00	0.000005	0.000360
21.50	0.000004	0.000316
22.00	0.000003	0.000278
22.50	0.000002	0.000243
23.00	0.000001	0.000213
23.50	0.000001	0.000186
24.00	0.000001	0.000162
24.50	0.000001	0.000141
25.00	0.000000	0.000123

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.197	2.480	2.252	1.883	2.194
20%	3.525	3.843	3.669	3.009	3.513
10%	4.372	4.613	4.500	3.692	4.329
5%	5.189	5.288	5.282	4.275	5.031
1%	7.672	6.590	6.833	5.421	6.653

Vguat (m/s)

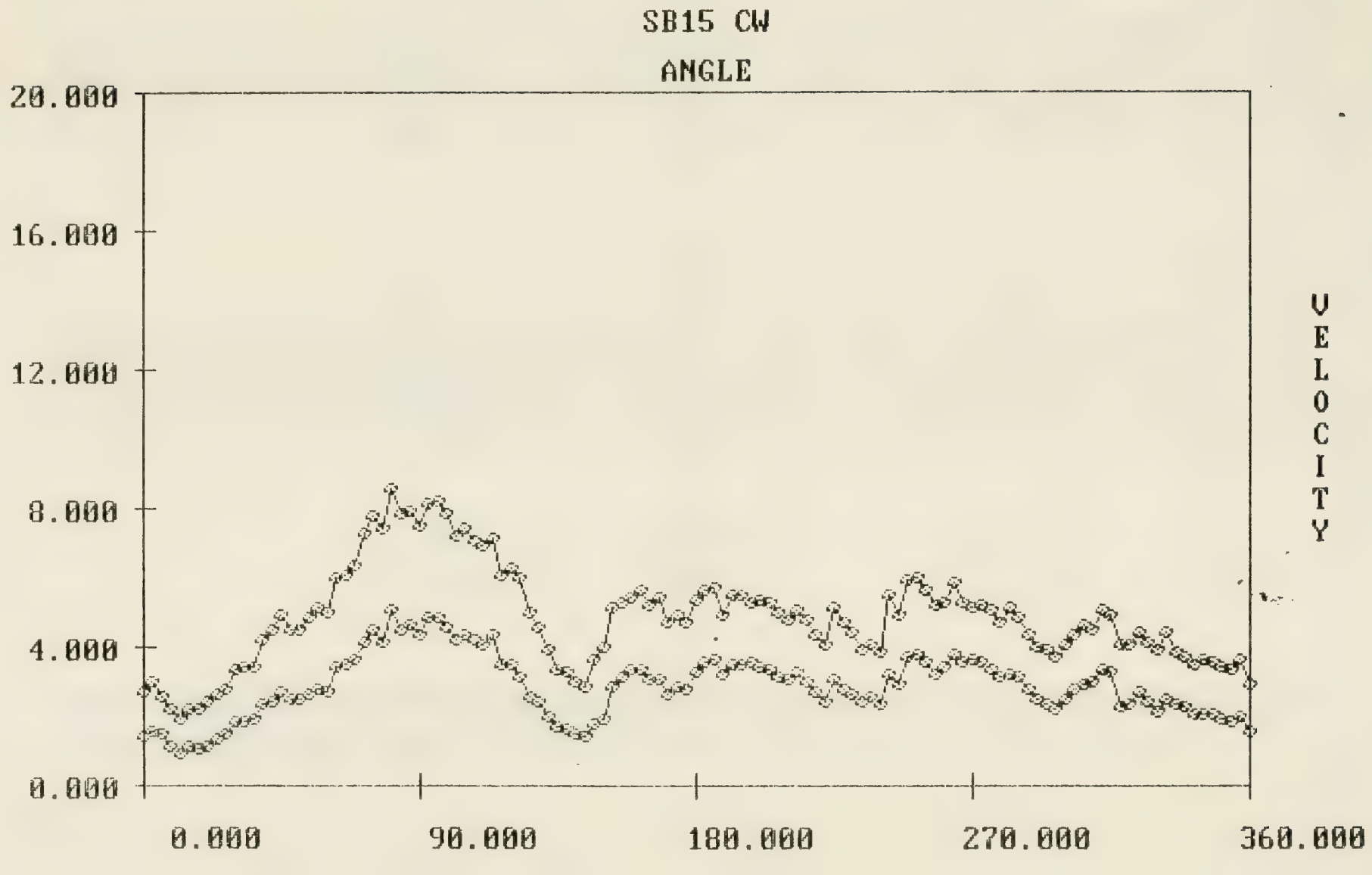
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.638	4.086	3.747	3.105	3.626
20%	5.784	6.212	5.986	4.907	5.742
10%	7.121	7.413	7.333	5.956	6.993
5%	8.444	8.454	8.511	6.889	8.153
1%	12.840	10.563	10.993	8.783	10.785

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.915	5.547	5.038	4.213	4.907
20%	7.886	8.597	8.207	6.732	7.858
10%	9.780	10.318	10.067	8.260	9.683
5%	11.607	11.829	11.815	9.562	11.255
1%	17.162	14.742	15.285	12.126	14.883

Vguat (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.138	9.140	8.382	6.945	8.110
20%	12.939	13.895	13.390	10.977	12.845
10%	15.929	16.583	16.403	13.323	15.643
5%	18.889	18.911	19.039	15.410	18.238
1%	28.723	23.630	24.590	19.647	24.125


SB15 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.955030	0.984079
1.00	0.848910	0.941650
1.50	0.716151	0.878735
2.00	0.578464	0.801957
2.50	0.448773	0.717419
3.00	0.335430	0.630106
3.50	0.242501	0.543875
4.00	0.170274	0.461660
4.50	0.116569	0.385618
5.00	0.078081	0.317194
5.50	0.051340	0.257164
6.00	0.033249	0.205708
6.50	0.021287	0.162531
7.00	0.013534	0.126994
7.50	0.008591	0.098249
8.00	0.005479	0.075361
8.50	0.003533	0.057389
9.00	0.002318	0.043452
9.50	0.001556	0.032759
10.00	0.001070	0.024632
10.50	0.000755	0.018504
11.00	0.000545	0.013912
11.50	0.000401	0.010488
12.00	0.000300	0.007944
12.50	0.000226	0.006056
13.00	0.000172	0.004655
13.50	0.000131	0.003614
14.00	0.000100	0.002837
14.50	0.000076	0.002253
15.00	0.000057	0.001812
15.50	0.000043	0.001474
16.00	0.000033	0.001213
16.50	0.000024	0.001009
17.00	0.000018	0.000846
17.50	0.000014	0.000715
18.00	0.000010	0.000609
18.50	0.000007	0.000520
19.00	0.000005	0.000446
19.50	0.000004	0.000384
20.00	0.000003	0.000330
20.50	0.000002	0.000285
21.00	0.000001	0.000245
21.50	0.000001	0.000211
22.00	0.000001	0.000182
22.50	0.000001	0.000156
23.00	0.000000	0.000134
23.50	0.000000	0.000115
24.00	0.000000	0.000099
24.50	0.000000	0.000084
25.00	0.000000	0.000072

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.301	2.610	2.341	1.994	2.303
20%	3.800	4.152	3.902	3.286	3.794
10%	4.756	5.056	4.872	4.044	4.715
5%	5.662	5.870	5.754	4.750	5.537
1%	7.877	7.472	7.567	6.133	7.358

Vgust (m/s)

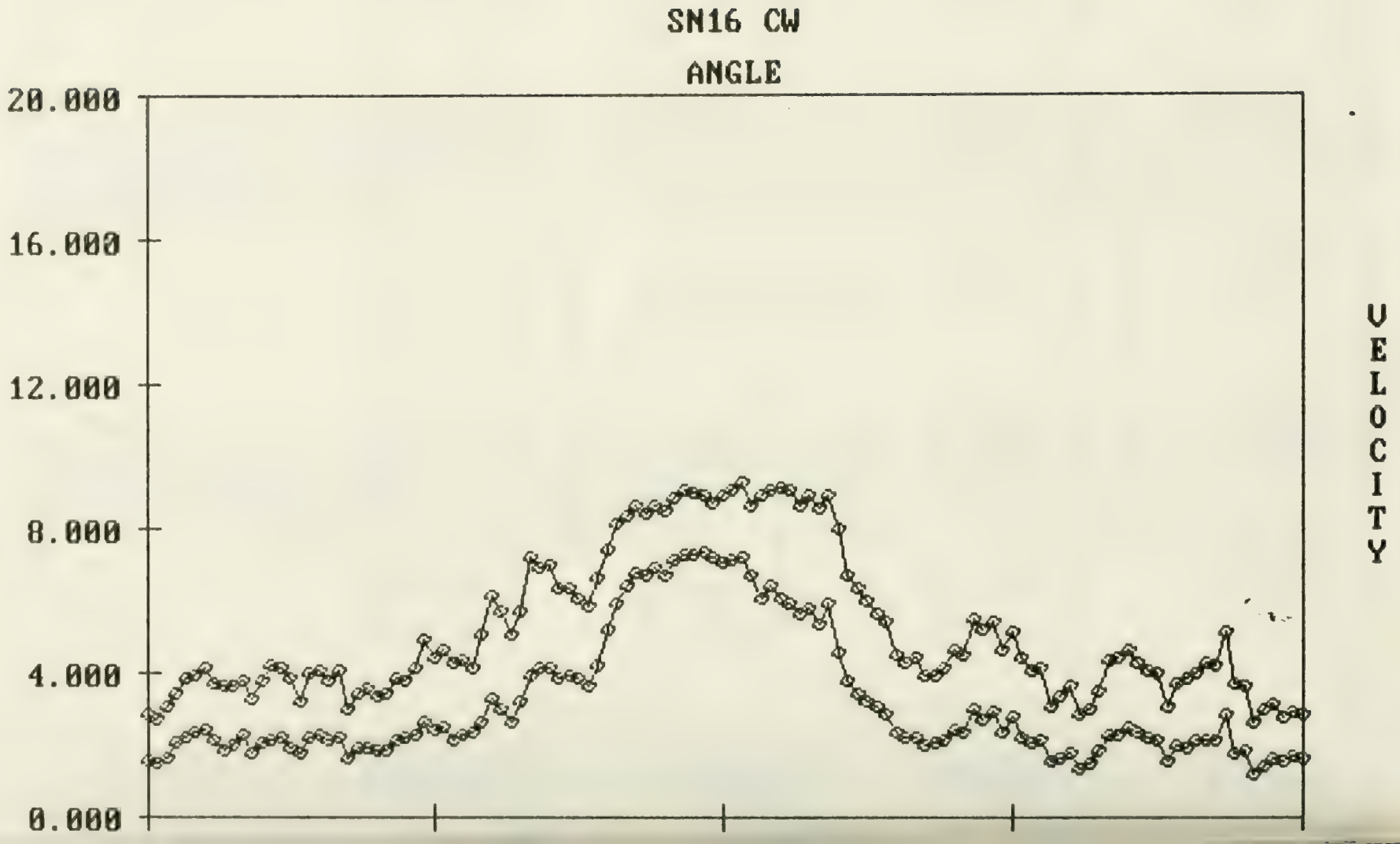
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.770	4.249	3.852	3.263	3.767
20%	6.099	6.590	6.279	5.254	6.066
10%	7.583	7.956	7.756	6.435	7.470
5%	9.021	9.174	9.077	7.484	8.765
1%	12.870	11.669	11.843	9.644	11.596

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.148	5.838	5.236	4.461	5.151
20%	8.500	9.289	8.728	7.352	8.487
10%	10.639	11.311	10.898	9.046	10.548
5%	12.666	13.131	12.872	10.626	12.386
1%	17.621	16.714	16.926	13.719	16.458

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.433	9.504	8.616	7.300	8.426
20%	13.644	14.742	14.046	11.752	13.569
10%	16.962	17.797	17.351	14.394	16.709
5%	20.180	20.522	20.305	16.740	19.607
1%	28.790	26.102	26.492	21.574	25.939


SN16 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.951976	0.985680
1.00	0.821833	0.944073
1.50	0.652441	0.879022
2.00	0.487892	0.797020
2.50	0.352366	0.705620
3.00	0.251024	0.611928
3.50	0.179316	0.521580
4.00	0.129977	0.438363
4.50	0.096247	0.364331
5.00	0.072906	0.300197
5.50	0.056322	0.245766
6.00	0.044141	0.200306
6.50	0.034902	0.162814
7.00	0.027711	0.132193
7.50	0.022018	0.107365
8.00	0.017464	0.087331
8.50	0.013809	0.071208
9.00	0.010873	0.058239
9.50	0.008522	0.047793
10.00	0.006647	0.039355
10.50	0.005159	0.032511
11.00	0.003985	0.026935
11.50	0.003064	0.022369
12.00	0.002345	0.018613
12.50	0.001788	0.015509
13.00	0.001358	0.012936
13.50	0.001028	0.010795
14.00	0.000775	0.009010
14.50	0.000583	0.007521
15.00	0.000437	0.006275
15.50	0.000327	0.005234
16.00	0.000244	0.004364
16.50	0.000182	0.003636
17.00	0.000135	0.003028
17.50	0.000100	0.002520
18.00	0.000074	0.002097
18.50	0.000055	0.001743
19.00	0.000040	0.001449
19.50	0.000030	0.001205
20.00	0.000022	0.001001
20.50	0.000016	0.000832
21.00	0.000012	0.000692
21.50	0.000008	0.000576
22.00	0.000006	0.000479
22.50	0.000004	0.000399
23.00	0.000003	0.000332
23.50	0.000002	0.000277
24.00	0.000002	0.000231
24.50	0.000001	0.000193
25.00	0.000001	0.000162

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.961	2.135	2.029	1.754	1.963
20%	3.427	3.468	3.472	2.985	3.356
10%	4.696	4.487	4.631	3.959	4.444
5%	6.203	5.792	5.951	5.052	5.760
1%	9.707	9.826	9.261	7.735	9.186

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.622	3.984	3.738	3.202	3.630
20%	6.117	6.356	6.220	5.323	6.004
10%	7.974	7.963	7.936	6.775	7.684
5%	9.968	9.659	9.653	8.208	9.394
1%	14.889	14.389	13.614	11.557	13.723

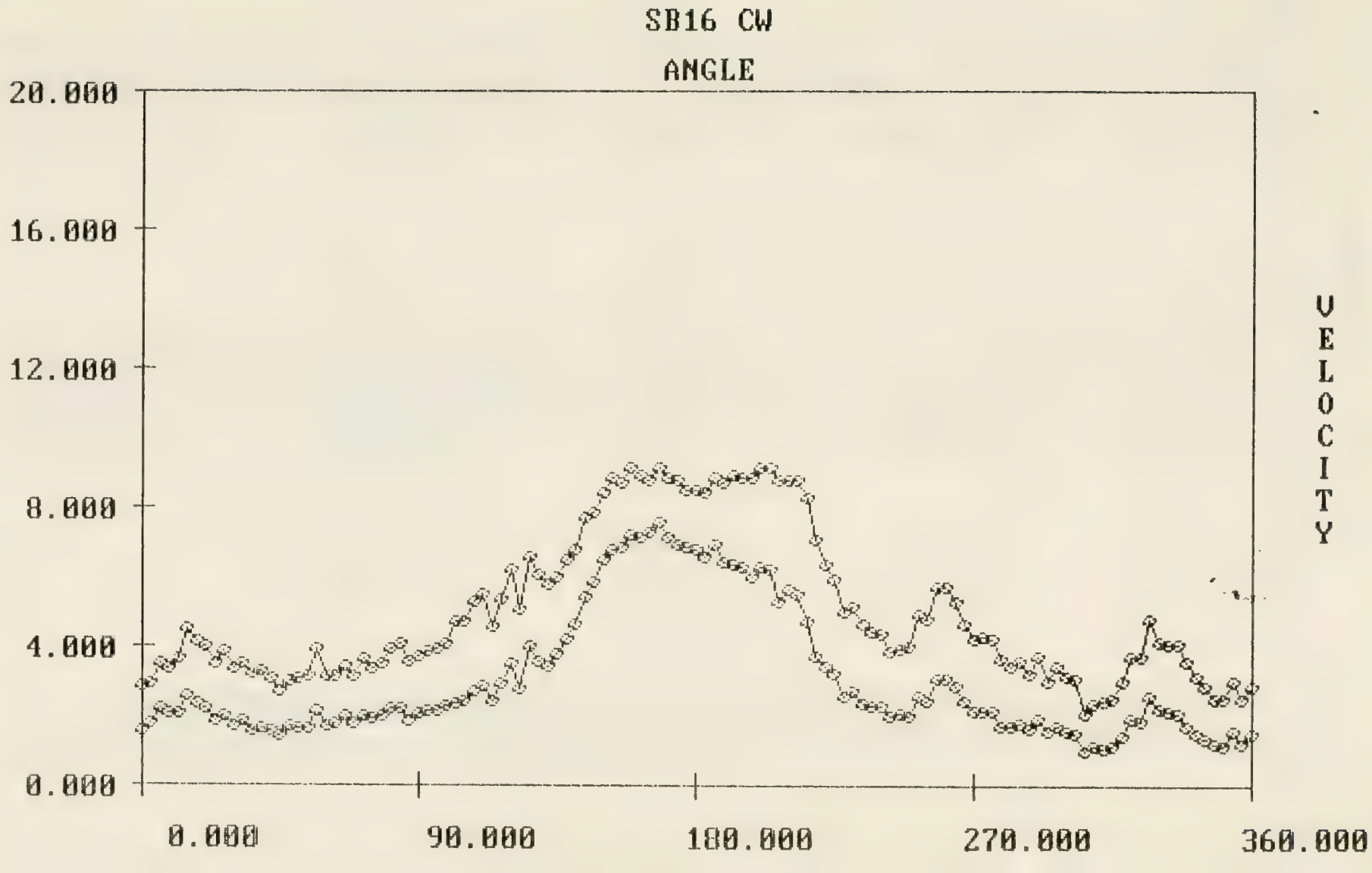
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.388	4.776	4.540	3.923	4.392
20%	7.666	7.757	7.767	6.677	7.507
10%	10.505	10.037	10.359	8.857	9.942
5%	13.876	12.956	13.312	11.302	12.884
1%	21.714	21.980	20.716	17.302	20.548

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.101	8.912	8.362	7.163	8.119
20%	13.684	14.218	13.913	11.907	13.431
10%	17.838	17.813	17.752	15.155	17.188
5%	22.299	21.606	21.593	18.360	21.015
1%	33.305	32.186	30.455	25.852	30.697

sn16


SB16 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.940264	0.983214
1.00	0.783018	0.933991
1.50	0.594700	0.857758
2.00	0.429806	0.763893
2.50	0.305762	0.662812
3.00	0.218569	0.563430
3.50	0.158869	0.471794
4.00	0.118050	0.390997
4.50	0.089653	0.321881
5.00	0.069326	0.263929
5.50	0.054307	0.215973
6.00	0.042891	0.176638
6.50	0.034013	0.144560
7.00	0.026999	0.118490
7.50	0.021402	0.097332
8.00	0.016914	0.080151
8.50	0.013311	0.066172
9.00	0.010423	0.054764
9.50	0.008118	0.045419
10.00	0.006287	0.037736
10.50	0.004842	0.031394
11.00	0.003707	0.026143
11.50	0.002823	0.021783
12.00	0.002139	0.018153
12.50	0.001612	0.015126
13.00	0.001209	0.012599
13.50	0.000902	0.010487
14.00	0.000671	0.008721
14.50	0.000497	0.007244
15.00	0.000366	0.006011
15.50	0.000269	0.004980
16.00	0.000197	0.004121
16.50	0.000144	0.003404
17.00	0.000104	0.002808
17.50	0.000076	0.002312
18.00	0.000055	0.001901
18.50	0.000039	0.001560
19.00	0.000028	0.001279
19.50	0.000020	0.001046
20.00	0.000014	0.000855
20.50	0.000010	0.000698
21.00	0.000007	0.000568
21.50	0.000005	0.000462
22.00	0.000004	0.000376
22.50	0.000003	0.000305
23.00	0.000002	0.000247
23.50	0.000001	0.000200
24.00	0.000001	0.000162
24.50	0.000001	0.000131
25.00	0.000000	0.000106

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.791	1.892	1.838	1.618	1.787
20%	3.281	3.198	3.272	2.886	3.156
10%	4.589	4.296	4.473	3.901	4.318
5%	6.095	5.721	5.894	5.017	5.689
1%	9.483	9.780	9.213	7.708	9.092

Vguat (m/s)

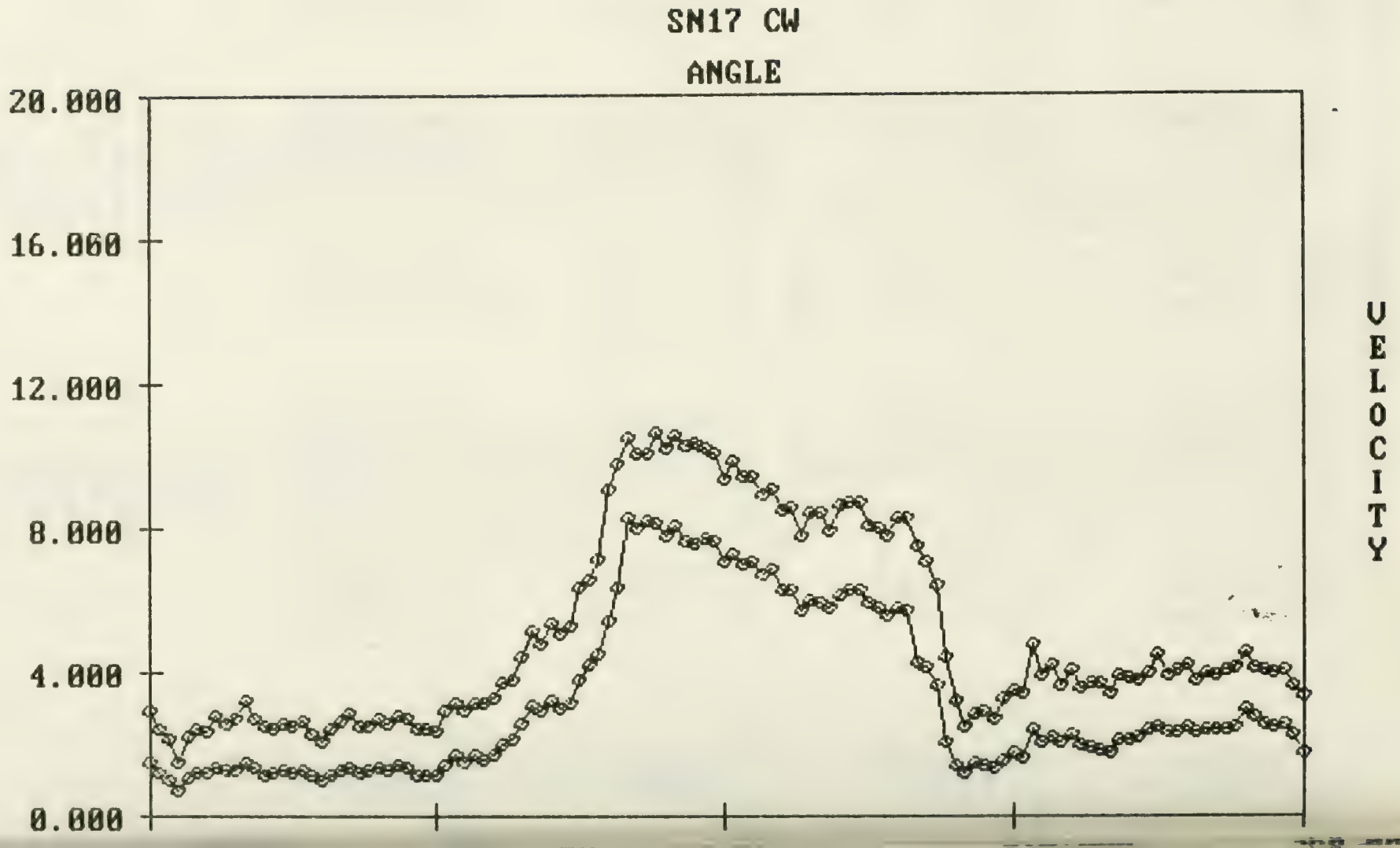
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.342	3.618	3.431	2.991	3.346
20%	5.868	5.910	5.874	5.142	5.703
10%	7.825	7.604	7.675	6.661	7.437
5%	9.848	9.462	9.484	8.158	9.255
1%	14.549	14.387	13.600	11.596	13.638

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.005	4.232	4.112	3.620	3.998
20%	7.339	7.155	7.318	6.455	7.059
10%	10.266	9.609	10.005	8.727	9.659
5%	13.633	12.798	13.184	11.223	12.725
1%	21.214	21.877	20.608	17.243	20.338

Vguat (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.475	8.094	7.675	6.691	7.485
20%	13.126	13.219	13.139	11.503	12.757
10%	17.503	17.010	17.168	14.900	16.636
5%	22.029	21.165	21.215	18.249	20.703
1%	32.544	32.183	30.422	25.940	30.507


SN17 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.932963	0.980150
1.00	0.784658	0.925808
1.50	0.628742	0.847761
2.00	0.492976	0.758176
2.50	0.381593	0.666534
3.00	0.294723	0.578571
3.50	0.230045	0.497181
4.00	0.183080	0.423683
4.50	0.148791	0.358648
5.00	0.122906	0.302205
5.50	0.102421	0.254102
6.00	0.085505	0.213733
6.50	0.071160	0.180233
7.00	0.058863	0.152598
7.50	0.048329	0.129809
8.00	0.039363	0.110927
8.50	0.031802	0.095146
9.00	0.025489	0.081815
9.50	0.020270	0.070432
10.00	0.015999	0.060621
10.50	0.012535	0.052105
11.00	0.009752	0.044683
11.50	0.007535	0.038204
12.00	0.005784	0.032552
12.50	0.004412	0.027632
13.00	0.003345	0.023363
13.50	0.002521	0.019674
14.00	0.001890	0.016502
14.50	0.001409	0.013786
15.00	0.001046	0.011472
15.50	0.000772	0.009510
16.00	0.000568	0.007854
16.50	0.000416	0.006463
17.00	0.000303	0.005300
17.50	0.000221	0.004331
18.00	0.000160	0.003528
18.50	0.000115	0.002865
19.00	0.000083	0.002319
19.50	0.000060	0.001871
20.00	0.000043	0.001506
20.50	0.000031	0.001209
21.00	0.000022	0.000967
21.50	0.000016	0.000772
22.00	0.000011	0.000615
22.50	0.000008	0.000489
23.00	0.000006	0.000387
23.50	0.000004	0.000306
24.00	0.000003	0.000242
24.50	0.000002	0.000190
25.00	0.000001	0.000149

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.966	2.187	2.017	1.739	1.974
20%	3.956	3.801	3.882	3.608	3.820
10%	5.947	5.408	5.605	5.338	5.572
5%	7.784	7.669	7.472	6.844	7.421
1%	11.149	11.916	10.951	9.625	10.955

Vgust (m/s)

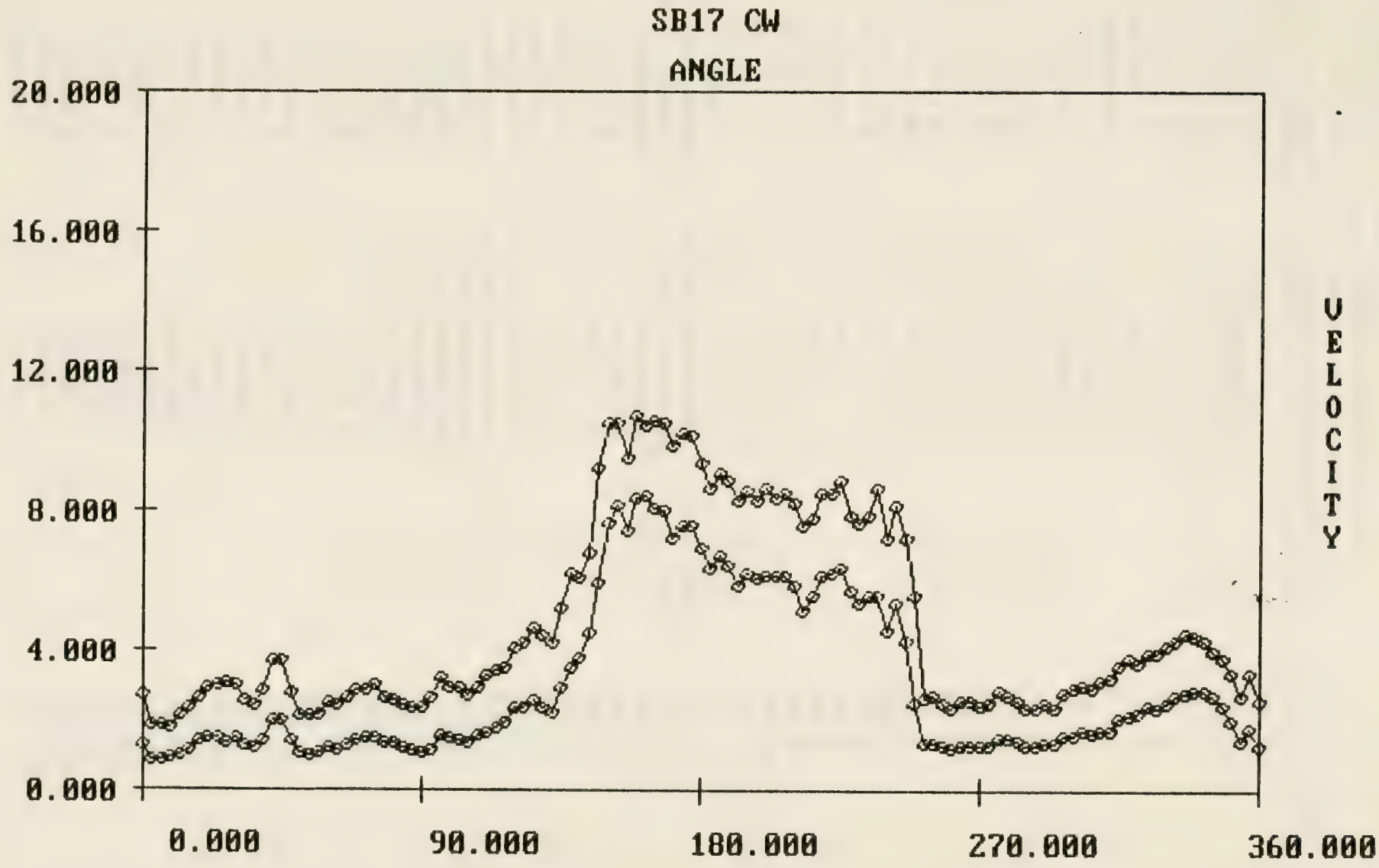
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.466	3.877	3.547	3.053	3.483
20%	6.336	6.400	6.332	5.665	6.205
10%	8.768	8.402	8.436	7.784	8.346
5%	11.191	10.988	10.675	9.783	10.642
1%	15.778	16.622	15.265	13.528	15.375

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.397	4.892	4.512	3.890	4.416
20%	8.850	8.504	8.684	8.071	8.545
10%	13.302	12.097	12.539	11.942	12.463
5%	17.411	17.155	16.715	15.310	16.600
1%	24.940	26.656	24.496	21.531	24.507

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.753	8.673	7.934	6.829	7.791
20%	14.172	14.316	14.164	12.672	13.880
10%	19.613	18.794	18.871	17.412	18.670
5%	25.033	24.580	23.878	21.885	23.805
1%	35.294	37.181	34.147	30.262	34.393


SB17 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.920290	0.976271
1.00	0.740620	0.909788
1.50	0.557871	0.813619
2.00	0.415643	0.704390
2.50	0.317128	0.596150
3.00	0.250941	0.497792
3.50	0.204777	0.413436
4.00	0.170363	0.343854
4.50	0.143107	0.287831
5.00	0.120567	0.243199
5.50	0.101405	0.207574
6.00	0.084864	0.178794
6.50	0.070513	0.155116
7.00	0.058094	0.135235
7.50	0.047430	0.118221
8.00	0.038367	0.103427
8.50	0.030754	0.090413
9.00	0.024436	0.078879
9.50	0.019252	0.068616
10.00	0.015045	0.059476
10.50	0.011667	0.051346
11.00	0.008981	0.044137
11.50	0.006865	0.037769
12.00	0.005213	0.032173
12.50	0.003933	0.027280
13.00	0.002950	0.023027
13.50	0.002199	0.019350
14.00	0.001631	0.016189
14.50	0.001203	0.013486
15.00	0.000883	0.011188
15.50	0.000645	0.009244
16.00	0.000469	0.007607
16.50	0.000340	0.006237
17.00	0.000245	0.005094
17.50	0.000176	0.004145
18.00	0.000126	0.003362
18.50	0.000090	0.002717
19.00	0.000064	0.002189
19.50	0.000045	0.001757
20.00	0.000032	0.001407
20.50	0.000022	0.001122
21.00	0.000016	0.000893
21.50	0.000011	0.000708
22.00	0.000008	0.000560
22.50	0.000005	0.000442
23.00	0.000004	0.000348
23.50	0.000003	0.000273
24.00	0.000002	0.000214
24.50	0.000001	0.000167
25.00	0.000001	0.000130

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.714	1.821	1.755	1.489	1.703
20%	3.806	3.403	3.582	3.534	3.569
10%	5.877	5.383	5.540	5.367	5.542
5%	7.666	7.677	7.422	6.849	7.379
1%	10.923	11.764	10.810	9.536	10.810

Vgust (m/s)

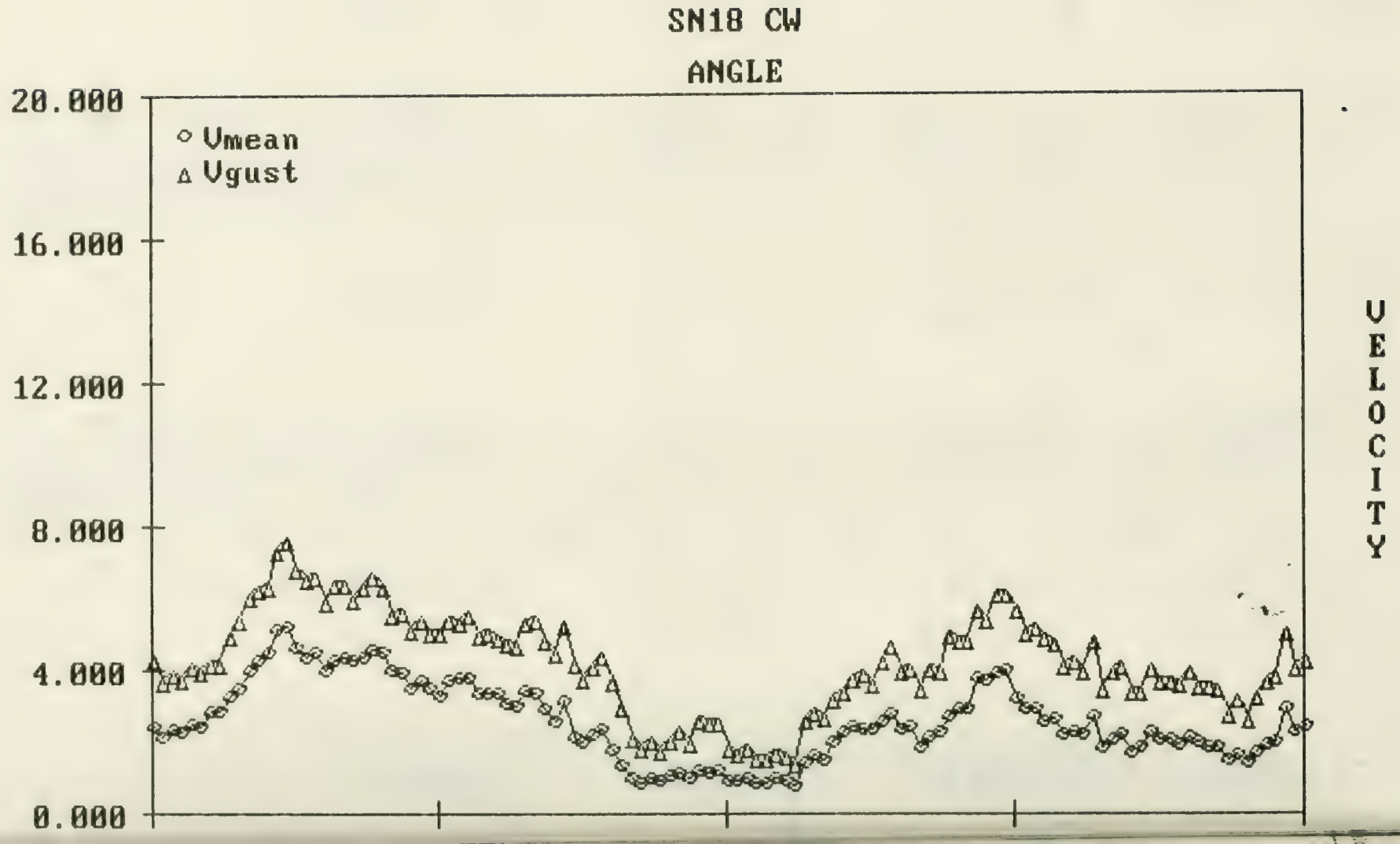
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.001	3.229	3.085	2.647	2.989
20%	5.901	5.572	5.695	5.350	5.632
10%	8.628	8.026	8.100	7.778	8.132
5%	11.067	11.002	10.575	9.827	10.593
1%	15.549	16.585	15.227	13.569	15.305

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.833	4.073	3.925	3.330	3.810
20%	8.513	7.612	8.013	7.905	7.985
10%	13.146	12.041	12.392	12.005	12.398
5%	17.149	17.173	16.603	15.320	16.507
1%	24.433	26.315	24.182	21.331	24.182

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.713	7.223	6.902	5.920	6.686
20%	13.200	12.464	12.739	11.968	12.597
10%	19.301	17.953	18.119	17.398	18.190
5%	24.757	24.611	23.657	21.981	23.697
1%	34.783	37.100	34.062	30.354	34.237


SN18 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
Umean
Ugust
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.931713	0.976136
1.00	0.796213	0.920114
1.50	0.640854	0.845041
2.00	0.487528	0.759592
2.50	0.352662	0.669284
3.00	0.245216	0.578203
3.50	0.165830	0.489888
4.00	0.110173	0.407356
4.50	0.072446	0.332843
5.00	0.047373	0.267650
5.50	0.030886	0.212185
6.00	0.020102	0.166136
6.50	0.013067	0.128702
7.00	0.008486	0.098815
7.50	0.005508	0.075308
8.00	0.003575	0.057048
8.50	0.002323	0.043007
9.00	0.001513	0.032298
9.50	0.000989	0.024182
10.00	0.000651	0.018065
10.50	0.000432	0.013473
11.00	0.000290	0.010039
11.50	0.000196	0.007478
12.00	0.000134	0.005572
12.50	0.000093	0.004157
13.00	0.000065	0.003107
13.50	0.000045	0.002329
14.00	0.000032	0.001752
14.50	0.000023	0.001323
15.00	0.000016	0.001005
15.50	0.000011	0.000768
16.00	0.000008	0.000590
16.50	0.000006	0.000457
17.00	0.000004	0.000356
17.50	0.000003	0.000279
18.00	0.000002	0.000221
18.50	0.000001	0.000175
19.00	0.000001	0.000140
19.50	0.000001	0.000112
20.00	0.000000	0.000091
20.50	0.000000	0.000073
21.00	0.000000	0.000059
21.50	0.000000	0.000048
22.00	0.000000	0.000039
22.50	0.000000	0.000032
23.00	0.000000	0.000026
23.50	0.000000	0.000021
24.00	0.000000	0.000017
24.50	0.000000	0.000014
25.00	0.000000	0.000011

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.960	2.214	1.993	1.693	1.959
20%	3.317	3.498	3.378	2.881	3.285
10%	4.228	4.340	4.294	3.634	4.135
5%	5.118	5.111	5.168	4.343	4.948
1%	7.256	6.839	7.135	5.874	6.835

Vguat (m/s)

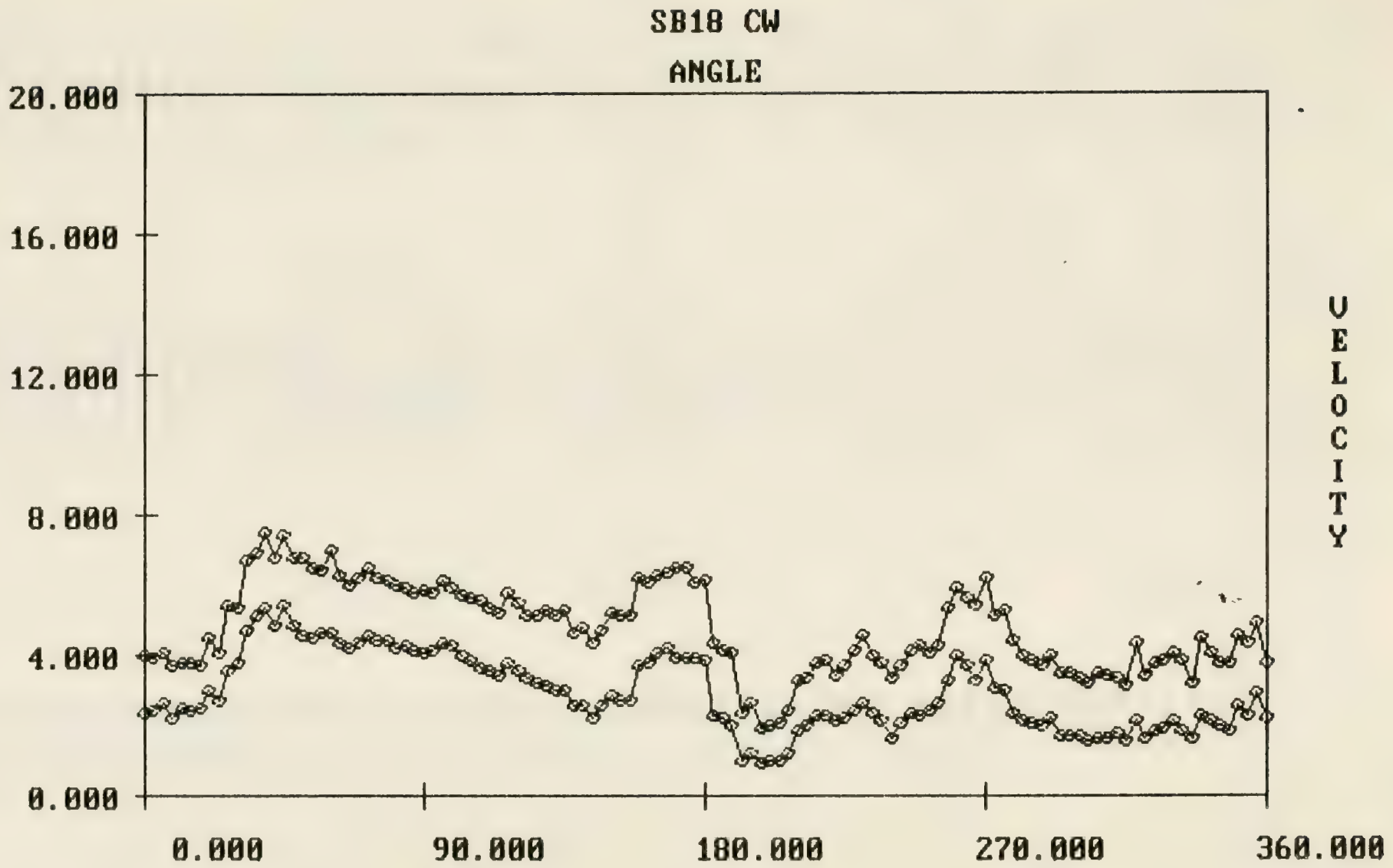
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.434	3.939	3.499	2.937	3.443
20%	5.633	6.151	5.780	4.891	5.632
10%	7.018	7.470	7.222	6.071	6.980
5%	8.363	8.679	8.565	7.146	8.251
1%	11.512	11.180	11.529	9.383	11.008

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.384	4.953	4.458	3.786	4.383
20%	7.420	7.825	7.557	6.445	7.348
10%	9.457	9.709	9.605	8.130	9.249
5%	11.449	11.433	11.561	9.715	11.068
1%	16.232	15.299	15.961	13.140	15.289

Vguat (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.681	8.811	7.826	6.570	7.701
20%	12.601	13.758	12.930	10.941	12.599
10%	15.698	16.711	16.156	13.580	15.614
5%	18.708	19.415	19.160	15.985	18.457
1%	25.751	25.010	25.789	20.988	24.623


SB18 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.948054	0.983345
1.00	0.817924	0.937729
1.50	0.650818	0.868706
2.00	0.483658	0.783028
2.50	0.341087	0.687682
3.00	0.232616	0.589170
3.50	0.156081	0.493059
4.00	0.104238	0.403675
4.50	0.069639	0.323940
5.00	0.046563	0.255373
5.50	0.031117	0.198277
6.00	0.020758	0.152035
6.50	0.013818	0.115448
7.00	0.009187	0.087048
7.50	0.006112	0.065326
8.00	0.004079	0.048894
8.50	0.002738	0.036556
9.00	0.001855	0.027333
9.50	0.001271	0.020457
10.00	0.000882	0.015333
10.50	0.000621	0.011515
11.00	0.000443	0.008669
11.50	0.000320	0.006544
12.00	0.000233	0.004957
12.50	0.000171	0.003770
13.00	0.000126	0.002880
13.50	0.000093	0.002212
14.00	0.000069	0.001708
14.50	0.000051	0.001328
15.00	0.000038	0.001039
15.50	0.000028	0.000819
16.00	0.000020	0.000650
16.50	0.000015	0.000519
17.00	0.000011	0.000416
17.50	0.000008	0.000336
18.00	0.000006	0.000273
18.50	0.000004	0.000222
19.00	0.000003	0.000181
19.50	0.000002	0.000148
20.00	0.000001	0.000122
20.50	0.000001	0.000100
21.00	0.000001	0.000082
21.50	0.000000	0.000067
22.00	0.000000	0.000055
22.50	0.000000	0.000045
23.00	0.000000	0.000037
23.50	0.000000	0.000030
24.00	0.000000	0.000025
24.50	0.000000	0.000020
25.00	0.000000	0.000016

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.950	2.161	2.020	1.694	1.951
20%	3.282	3.371	3.341	2.826	3.213
10%	4.240	4.194	4.259	3.562	4.061
5%	5.216	4.982	5.167	4.296	4.926
1%	7.611	6.785	7.181	5.860	6.912

Vgust (m/s)

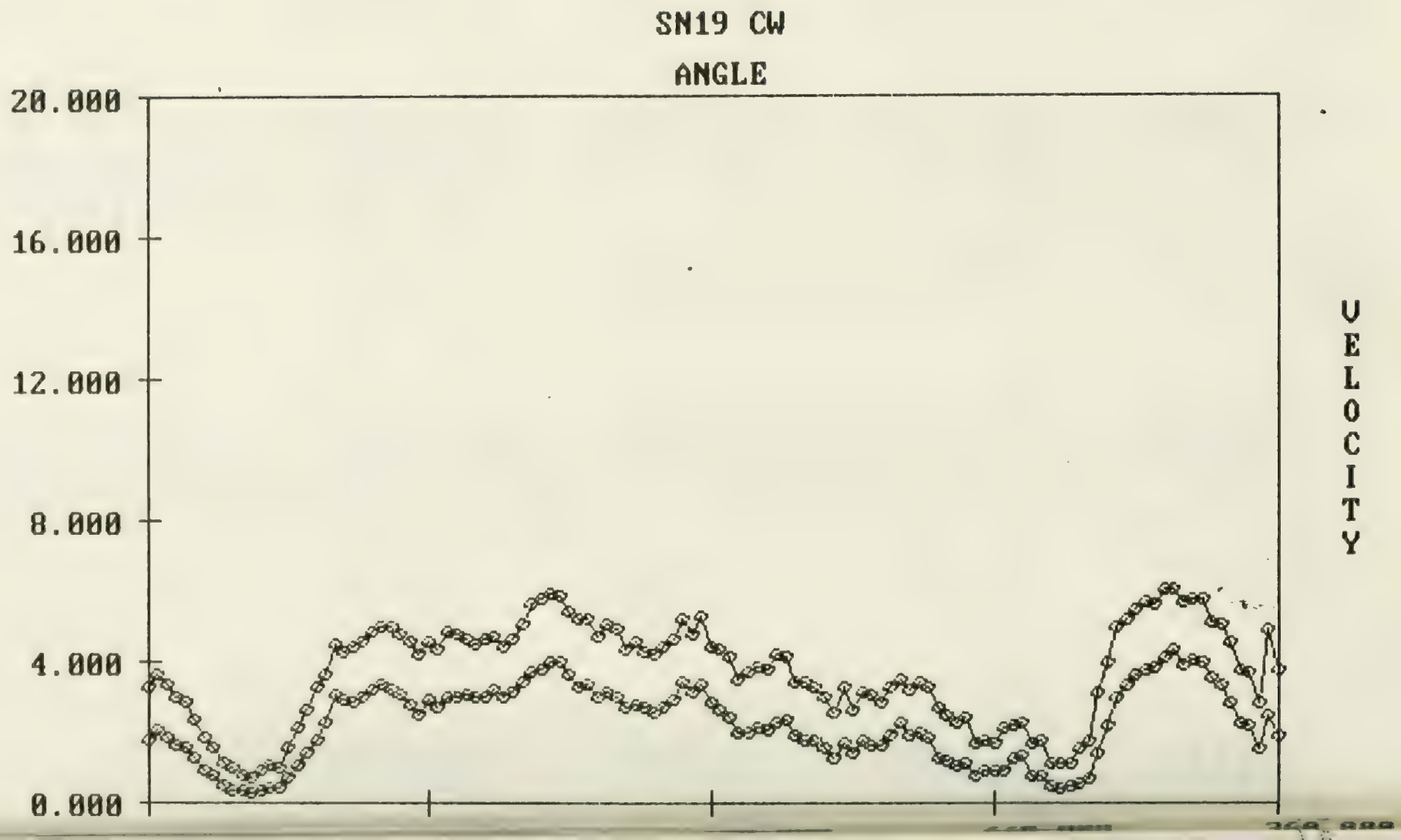
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.455	3.906	3.579	2.959	3.464
20%	5.521	5.914	5.694	4.757	5.485
10%	6.889	7.144	7.019	5.861	6.772
5%	8.239	8.287	8.299	6.878	7.966
1%	11.646	10.781	11.160	9.059	10.766

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.363	4.834	4.519	3.790	4.365
20%	7.342	7.542	7.474	6.321	7.187
10%	9.484	9.381	9.527	7.969	9.085
5%	11.669	11.145	11.558	9.609	11.018
1%	17.025	15.177	16.063	13.108	15.462

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.728	8.738	8.006	6.619	7.749
20%	12.351	13.230	12.738	10.641	12.269
10%	15.410	15.981	15.702	13.111	15.148
5%	18.431	18.538	18.564	15.387	17.820
1%	26.051	24.117	24.964	20.265	24.083


SN19 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.852544	0.955583
1.00	0.633875	0.853154
1.50	0.455864	0.729058
2.00	0.323029	0.604952
2.50	0.227853	0.492239
3.00	0.161131	0.395190
3.50	0.114537	0.314305
4.00	0.081686	0.248330
4.50	0.058191	0.195279
5.00	0.041187	0.153026
5.50	0.028826	0.119590
6.00	0.019886	0.093235
6.50	0.013504	0.072505
7.00	0.009033	0.056211
7.50	0.005967	0.043412
8.00	0.003911	0.033370
8.50	0.002558	0.025512
9.00	0.001683	0.019389
9.50	0.001121	0.014644
10.00	0.000762	0.010995
10.50	0.000531	0.008212
11.00	0.000379	0.006107
11.50	0.000277	0.004531
12.00	0.000206	0.003361
12.50	0.000155	0.002498
13.00	0.000117	0.001867
13.50	0.000089	0.001406
14.00	0.000068	0.001071
14.50	0.000051	0.000826
15.00	0.000039	0.000646
15.50	0.000029	0.000512
16.00	0.000022	0.000411
16.50	0.000016	0.000334
17.00	0.000012	0.000274
17.50	0.000009	0.000227
18.00	0.000006	0.000189
18.50	0.000005	0.000157
19.00	0.000003	0.000131
19.50	0.000002	0.000110
20.00	0.000002	0.000092
20.50	0.000001	0.000077
21.00	0.000001	0.000064
21.50	0.000001	0.000053
22.00	0.000000	0.000044
22.50	0.000000	0.000037
23.00	0.000000	0.000030
23.50	0.000000	0.000025
24.00	0.000000	0.000021
24.50	0.000000	0.000017
25.00	0.000000	0.000014

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.412	1.489	1.468	1.167	1.376
20%	2.801	3.059	2.868	2.167	2.709
10%	3.840	4.226	3.897	2.864	3.721
5%	4.896	5.281	4.913	3.541	4.741
1%	7.341	7.276	6.994	5.193	6.892

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.511	2.738	2.624	2.085	2.466
20%	4.581	5.012	4.694	3.626	4.456
10%	6.008	6.599	6.110	4.639	5.872
5%	7.430	8.004	7.462	5.594	7.243
1%	10.816	10.733	10.318	7.761	10.179

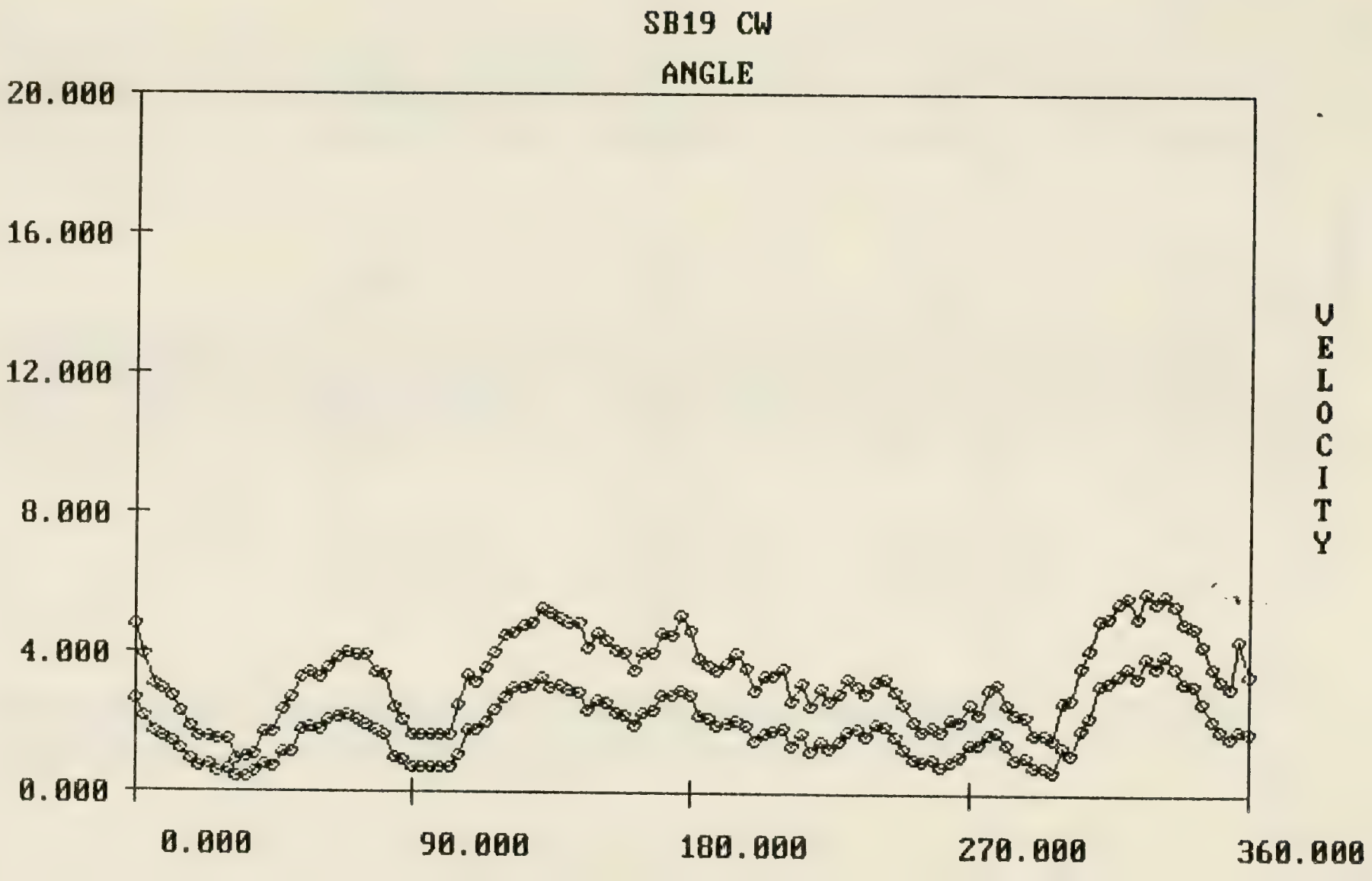
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.158	3.332	3.283	2.611	3.078
20%	6.267	6.843	6.415	4.847	6.059
10%	8.591	9.454	8.717	6.406	8.324
5%	10.953	11.814	10.991	7.920	10.605
1%	16.422	16.275	15.644	11.616	15.417

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.617	6.124	5.870	4.664	5.515
20%	10.247	11.212	10.501	8.112	9.967
10%	13.439	14.761	13.667	10.377	13.135
5%	16.619	17.904	16.693	12.513	16.201
1%	24.195	24.010	23.081	17.360	22.769

\nb17\sn19


SB19 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.867894	0.960790
1.00	0.631636	0.864100
1.50	0.425469	0.738961
2.00	0.279319	0.607561
2.50	0.183967	0.484741
3.00	0.123197	0.378564
3.50	0.083896	0.291509
4.00	0.057609	0.222607
4.50	0.039439	0.169285
5.00	0.026652	0.128544
5.50	0.017656	0.097589
6.00	0.011424	0.074075
6.50	0.007214	0.056168
7.00	0.004453	0.042484
7.50	0.002698	0.032002
8.00	0.001613	0.023972
8.50	0.000960	0.017836
9.00	0.000574	0.013169
9.50	0.000348	0.009647
10.00	0.000216	0.007011
10.50	0.000137	0.005059
11.00	0.000090	0.003629
11.50	0.000060	0.002592
12.00	0.000041	0.001849
12.50	0.000028	0.001320
13.00	0.000019	0.000946
13.50	0.000013	0.000684
14.00	0.000009	0.000500
14.50	0.000006	0.000370
15.00	0.000004	0.000278
15.50	0.000003	0.000212
16.00	0.000002	0.000163
16.50	0.000001	0.000128
17.00	0.000001	0.000100
17.50	0.000000	0.000080
18.00	0.000000	0.000063
18.50	0.000000	0.000050
19.00	0.000000	0.000040
19.50	0.000000	0.000032
20.00	0.000000	0.000025
20.50	0.000000	0.000020
21.00	0.000000	0.000016
21.50	0.000000	0.000013
22.00	0.000000	0.000010
22.50	0.000000	0.000008
23.00	0.000000	0.000006
23.50	0.000000	0.000005
24.00	0.000000	0.000004
24.50	0.000000	0.000003
25.00	0.000000	0.000002

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.321	1.499	1.379	1.102	1.319
20%	2.435	2.792	2.530	1.937	2.416
10%	3.325	3.788	3.441	2.527	3.295
5%	4.252	4.751	4.388	3.175	4.209
1%	6.309	6.593	6.357	4.699	6.169

Vgust (m/s)

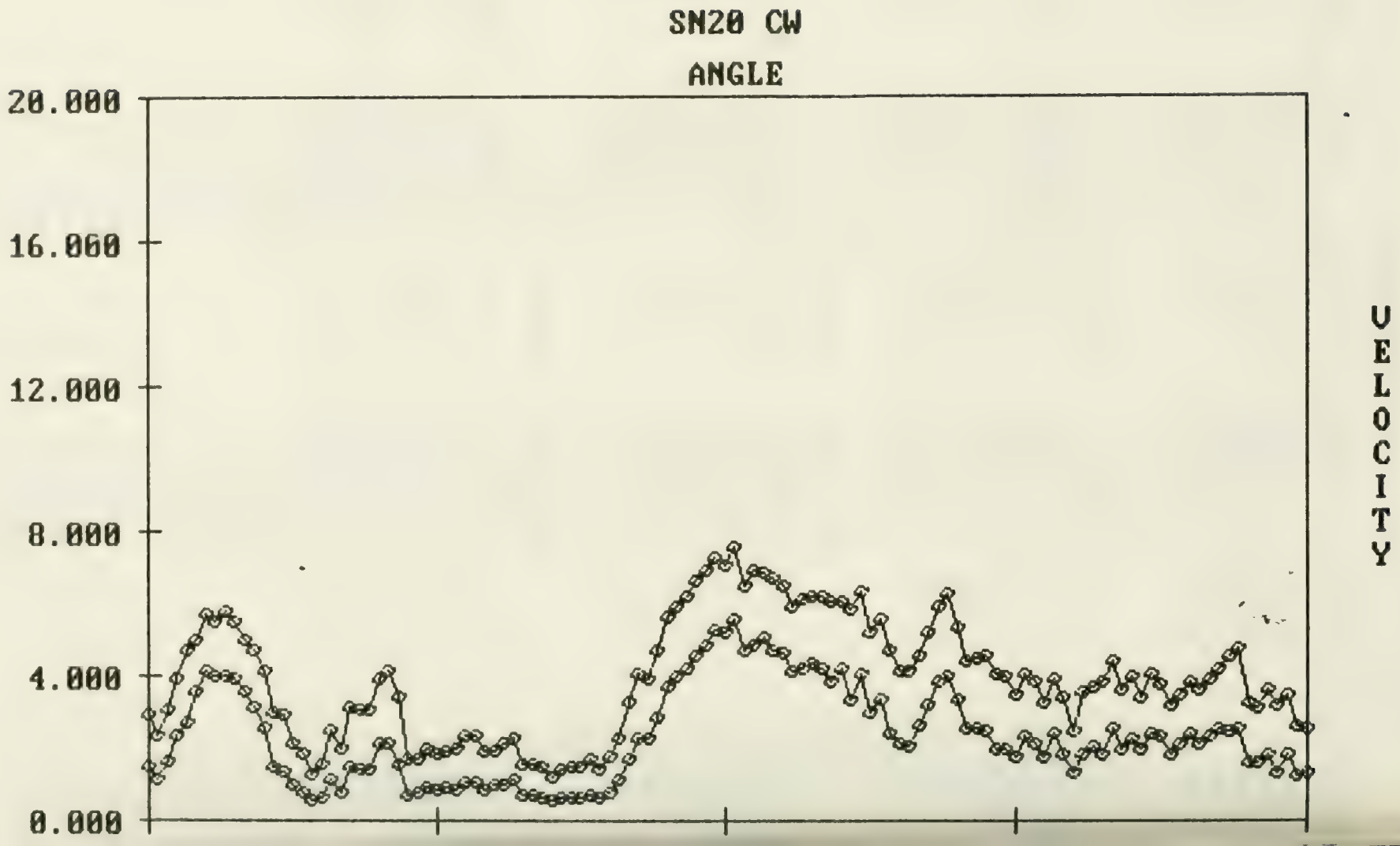
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.442	2.810	2.551	2.038	2.438
20%	4.239	4.791	4.408	3.417	4.212
10%	5.493	6.186	5.702	4.342	5.461
5%	6.781	7.482	6.959	5.235	6.725
1%	9.738	10.074	9.685	7.282	9.450

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.955	3.353	3.085	2.466	2.951
20%	5.446	6.246	5.659	4.334	5.404
10%	7.439	8.474	7.697	5.653	7.371
5%	9.512	10.627	9.816	7.103	9.416
1%	14.112	14.748	14.221	10.511	13.800

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.463	6.285	5.706	4.560	5.453
20%	9.482	10.717	9.860	7.645	9.422
10%	12.287	13.839	12.756	9.713	12.216
5%	15.168	16.737	15.566	11.710	15.044
1%	21.783	22.535	21.664	16.290	21.139


SN20 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

elocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.916983	0.974275
1.00	0.772470	0.912010
1.50	0.619994	0.830680
2.00	0.473620	0.741159
2.50	0.346640	0.648830
3.00	0.245549	0.557321
3.50	0.170299	0.469879
4.00	0.116910	0.389209
4.50	0.080105	0.317167
5.00	0.055021	0.254687
5.50	0.037906	0.201891
6.00	0.026143	0.158291
6.50	0.017997	0.122991
7.00	0.012334	0.094885
7.50	0.008398	0.072810
8.00	0.005676	0.055655
8.50	0.003806	0.042426
9.00	0.002532	0.032278
9.50	0.001673	0.024519
10.00	0.001098	0.018597
10.50	0.000716	0.014082
11.00	0.000465	0.010642
11.50	0.000301	0.008023
12.00	0.000194	0.006032
12.50	0.000125	0.004520
13.00	0.000081	0.003375
13.50	0.000052	0.002511
14.00	0.000033	0.001861
14.50	0.000021	0.001373
15.00	0.000014	0.001010
15.50	0.000009	0.000739
16.00	0.000006	0.000539
16.50	0.000004	0.000392
17.00	0.000002	0.000283
17.50	0.000002	0.000204
18.00	0.000001	0.000147
18.50	0.000001	0.000105
19.00	0.000000	0.000075
19.50	0.000000	0.000054
20.00	0.000000	0.000038
20.50	0.000000	0.000027
21.00	0.000000	0.000019
21.50	0.000000	0.000014
22.00	0.000000	0.000010
22.50	0.000000	0.000007
23.00	0.000000	0.000005
23.50	0.000000	0.000003
24.00	0.000000	0.000002
24.50	0.000000	0.000002
25.00	0.000000	0.000001

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.873	2.162	1.934	1.691	1.910
20%	3.270	3.503	3.407	2.954	3.303
10%	4.236	4.428	4.366	3.825	4.230
5%	5.205	5.404	5.297	4.649	5.147
1%	7.344	7.898	7.386	6.403	7.297

Vgust (m/s)

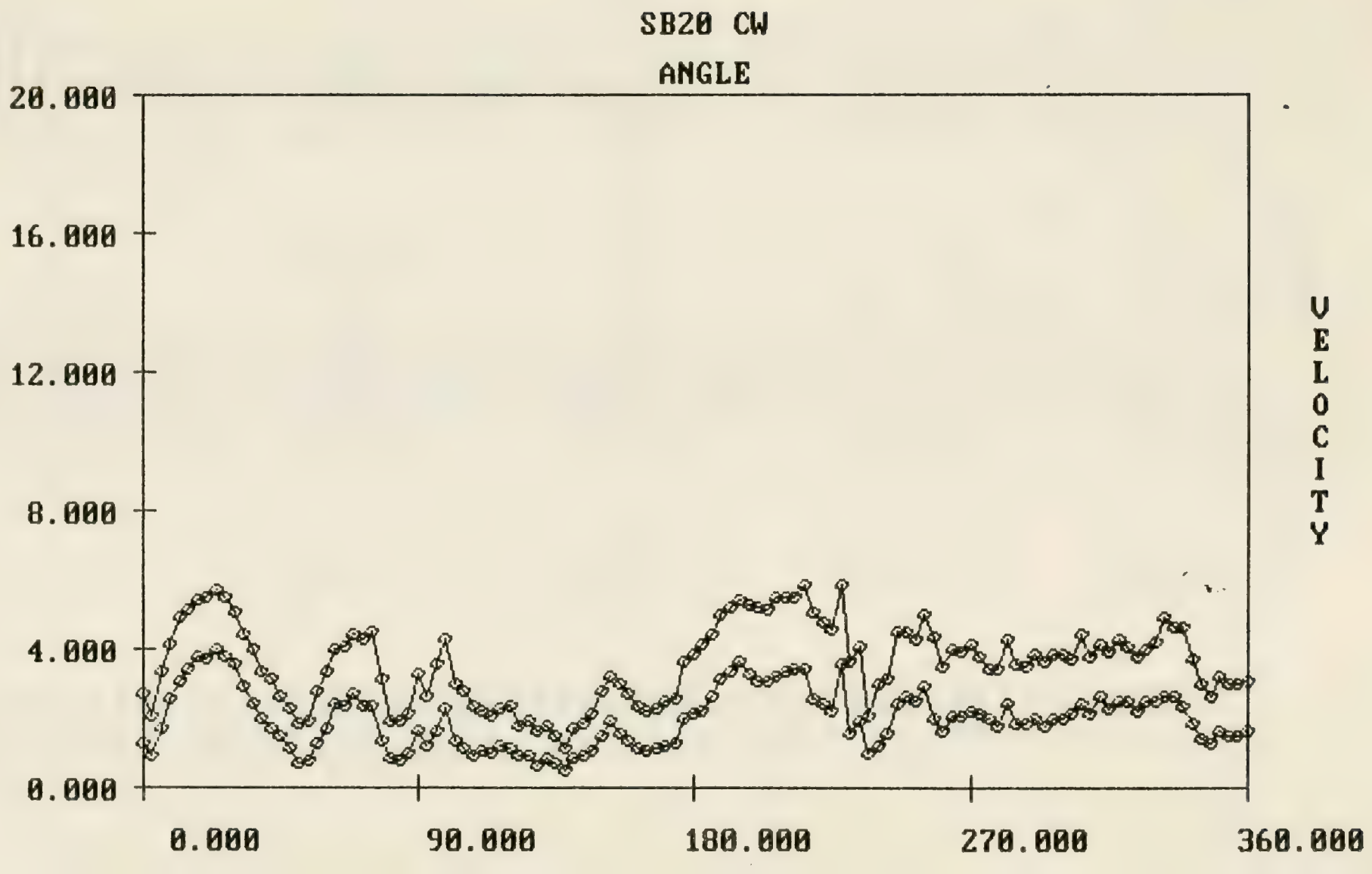
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.277	3.778	3.364	2.919	3.328
20%	5.454	5.967	5.692	4.923	5.522
10%	6.874	7.354	7.124	6.186	6.909
5%	8.225	8.703	8.436	7.344	8.214
1%	11.152	11.983	11.276	9.783	11.123

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.189	4.836	4.325	3.783	4.272
20%	7.314	7.835	7.622	6.607	7.388
10%	9.476	9.906	9.767	8.556	9.462
5%	11.644	12.088	11.849	10.399	11.513
1%	16.427	17.667	16.523	14.323	16.322

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.331	8.452	7.525	6.530	7.444
20%	12.201	13.349	12.733	11.013	12.352
10%	15.377	16.450	15.935	13.838	15.455
5%	18.399	19.469	18.871	16.428	18.374
1%	24.945	26.805	25.224	21.883	24.881


SB20 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.914792	0.973999
1.00	0.750219	0.910633
1.50	0.575213	0.824802
2.00	0.415267	0.728084
2.50	0.283196	0.628361
3.00	0.183254	0.530853
3.50	0.113275	0.439199
4.00	0.067478	0.355953
4.50	0.039124	0.282711
5.00	0.022294	0.220172
5.50	0.012587	0.168271
6.00	0.007081	0.126341
6.50	0.003980	0.093315
7.00	0.002235	0.067908
7.50	0.001253	0.048782
8.00	0.000699	0.034659
8.50	0.000388	0.024407
9.00	0.000213	0.017069
9.50	0.000116	0.011878
10.00	0.000063	0.008238
10.50	0.000033	0.005701
11.00	0.000018	0.003941
11.50	0.000009	0.002722
12.00	0.000005	0.001880
12.50	0.000002	0.001297
13.00	0.000001	0.000894
13.50	0.000001	0.000616
14.00	0.000000	0.000424
14.50	0.000000	0.000291
15.00	0.000000	0.000199
15.50	0.000000	0.000136
16.00	0.000000	0.000093
16.50	0.000000	0.000063
17.00	0.000000	0.000043
17.50	0.000000	0.000029
18.00	0.000000	0.000019
18.50	0.000000	0.000013
19.00	0.000000	0.000009
19.50	0.000000	0.000006
20.00	0.000000	0.000004
20.50	0.000000	0.000002
21.00	0.000000	0.000002
21.50	0.000000	0.000001
22.00	0.000000	0.000001
22.50	0.000000	0.000000
23.00	0.000000	0.000000
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.718	2.013	1.771	1.465	1.735
20%	2.867	3.230	3.031	2.484	2.916
10%	3.573	3.931	3.804	3.140	3.645
5%	4.253	4.579	4.455	3.740	4.308
1%	5.722	6.055	5.854	5.011	5.735

Vgust (m/s)

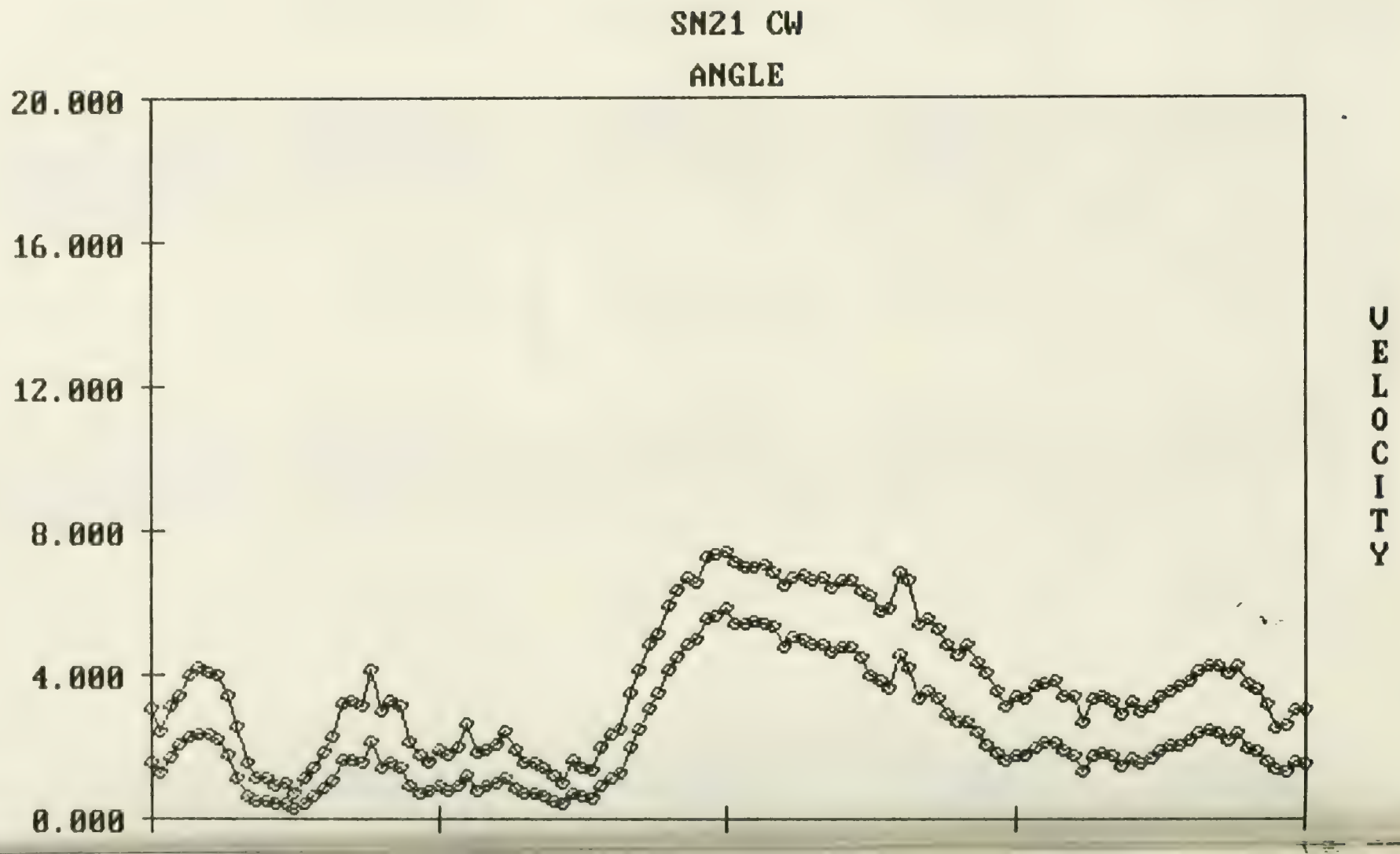
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.145	3.669	3.223	2.704	3.168
20%	5.110	5.740	5.370	4.463	5.194
10%	6.304	6.927	6.636	5.521	6.399
5%	7.381	7.982	7.748	6.476	7.468
1%	9.711	10.337	9.981	8.486	9.758

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.842	4.502	3.961	3.277	3.881
20%	6.414	7.225	6.781	5.557	6.523
10%	7.993	8.793	8.509	7.023	8.153
5%	9.513	10.242	9.965	8.366	9.637
1%	12.800	13.544	13.094	11.208	12.829

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.035	8.208	7.209	6.048	7.087
20%	11.431	12.839	12.011	9.982	11.619
10%	14.102	15.494	14.845	12.350	14.314
5%	16.511	17.855	17.333	14.486	16.706
1%	21.723	23.123	22.327	18.983	21.828


SN21 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

elocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.895915	0.965058
1.00	0.746061	0.891391
1.50	0.589371	0.805436
2.00	0.443367	0.714244
2.50	0.323846	0.620932
3.00	0.234527	0.529264
3.50	0.171043	0.443017
4.00	0.126469	0.365068
4.50	0.094652	0.297037
5.00	0.071273	0.239365
5.50	0.053653	0.191605
6.00	0.040187	0.152748
6.50	0.029866	0.121524
7.00	0.021993	0.096620
7.50	0.016039	0.076823
8.00	0.011585	0.061087
8.50	0.008290	0.048558
9.00	0.005879	0.038557
9.50	0.004133	0.030558
10.00	0.002882	0.024153
10.50	0.001995	0.019026
11.00	0.001371	0.014928
11.50	0.000936	0.011663
12.00	0.000635	0.009070
12.50	0.000428	0.007021
13.00	0.000287	0.005409
13.50	0.000192	0.004147
14.00	0.000128	0.003165
14.50	0.000085	0.002404
15.00	0.000056	0.001818
15.50	0.000037	0.001369
16.00	0.000024	0.001026
16.50	0.000016	0.000766
17.00	0.000010	0.000570
17.50	0.000007	0.000422
18.00	0.000004	0.000311
18.50	0.000003	0.000229
19.00	0.000002	0.000167
19.50	0.000001	0.000122
20.00	0.000001	0.000089
20.50	0.000000	0.000064
21.00	0.000000	0.000046
21.50	0.000000	0.000033
22.00	0.000000	0.000024
22.50	0.000000	0.000017
23.00	0.000000	0.000012
23.50	0.000000	0.000009
24.00	0.000000	0.000006
24.50	0.000000	0.000004
25.00	0.000000	0.000003

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.774	1.996	1.807	1.630	1.806
20%	3.299	3.347	3.342	3.061	3.272
10%	4.553	4.445	4.493	4.173	4.416
5%	5.828	5.843	5.727	5.208	5.636
1%	8.349	8.960	8.264	7.249	8.241

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.126	3.561	3.180	2.814	3.170
20%	5.402	5.720	5.542	4.923	5.412
10%	7.017	7.208	7.102	6.366	6.932
5%	8.622	8.834	8.598	7.725	8.442
1%	11.947	12.808	11.823	10.474	11.821

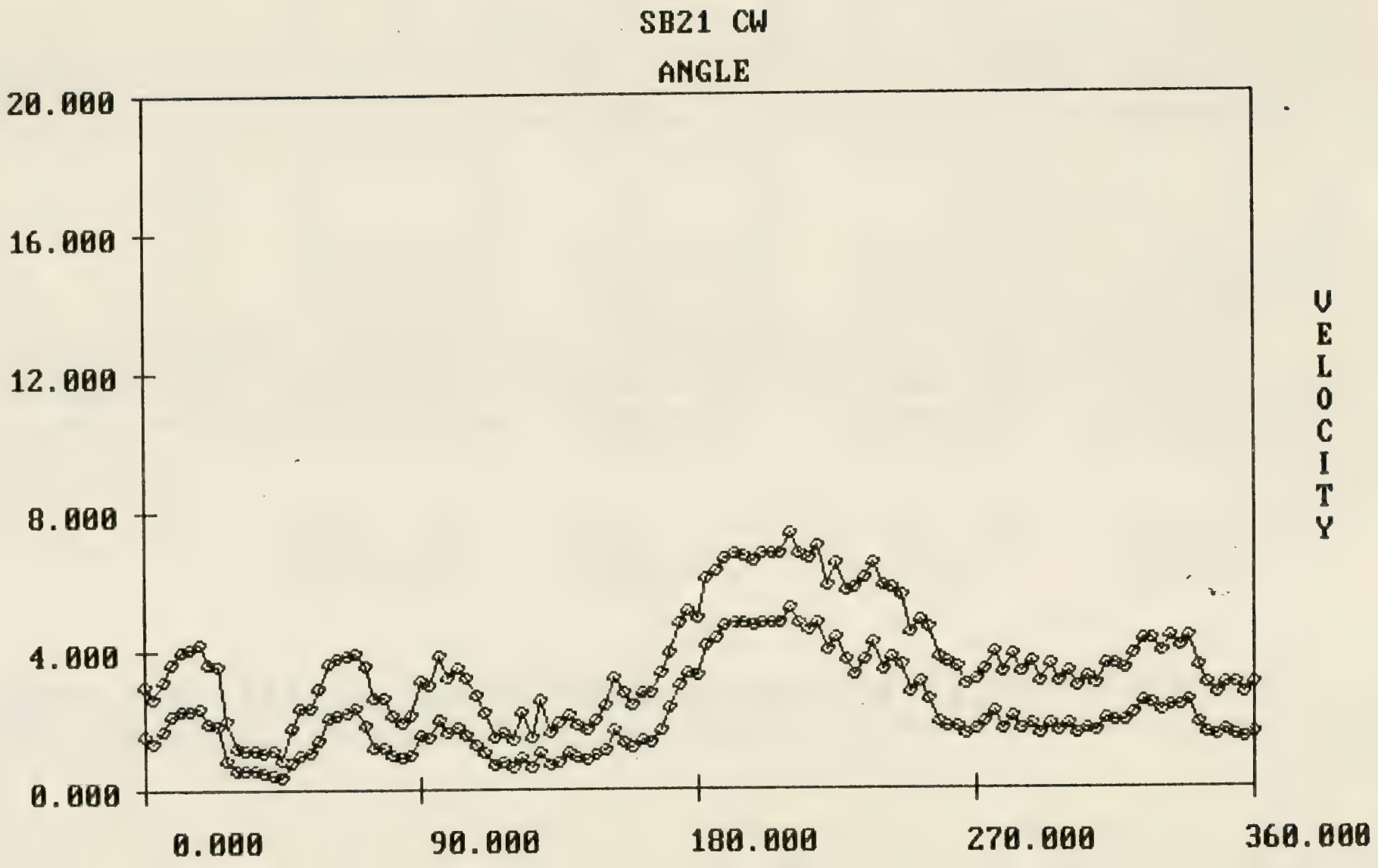
Vmean (mph)

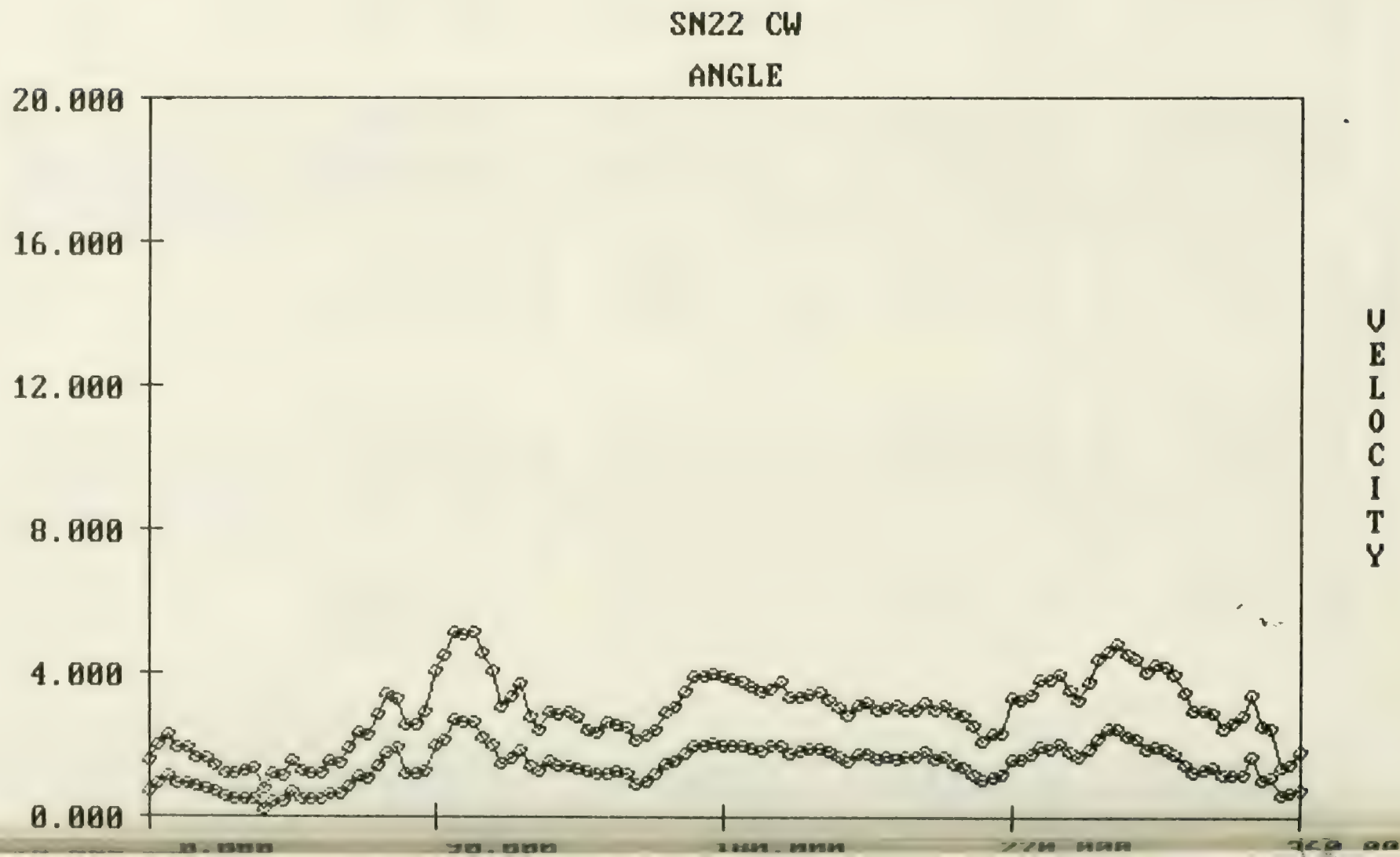
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.968	4.465	4.043	3.646	4.040
20%	7.379	7.488	7.475	6.847	7.319
10%	10.184	9.942	10.050	9.336	9.878
5%	13.037	13.071	12.811	11.650	12.607
1%	18.676	20.043	18.487	16.215	18.434

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.993	7.966	7.113	6.294	7.090
20%	12.084	12.796	12.398	11.013	12.107
10%	15.697	16.123	15.888	14.239	15.507
5%	19.286	19.761	19.233	17.280	18.885
1%	26.725	28.650	26.446	23.430	26.442

\nb17\sn21


SB21 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000


SN22 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.847476	0.955441
1.00	0.620733	0.853990
1.50	0.415672	0.734141
2.00	0.254954	0.615117
2.50	0.144535	0.503405
3.00	0.076393	0.402176
3.50	0.037947	0.313773
4.00	0.017871	0.239400
4.50	0.008058	0.178950
5.00	0.003514	0.131286
5.50	0.001499	0.094679
6.00	0.000633	0.067202
6.50	0.000269	0.046993
7.00	0.000117	0.032400
7.50	0.000052	0.022041
8.00	0.000024	0.014805
8.50	0.000012	0.009825
9.00	0.000006	0.006449
9.50	0.000003	0.004192
10.00	0.000001	0.002703
10.50	0.000001	0.001732
11.00	0.000000	0.001107
11.50	0.000000	0.000707
12.00	0.000000	0.000453
12.50	0.000000	0.000293
13.00	0.000000	0.000191
13.50	0.000000	0.000126
14.00	0.000000	0.000085
14.50	0.000000	0.000058
15.00	0.000000	0.000040
15.50	0.000000	0.000027
16.00	0.000000	0.000019
16.50	0.000000	0.000013
17.00	0.000000	0.000009
17.50	0.000000	0.000007
18.00	0.000000	0.000005
18.50	0.000000	0.000003
19.00	0.000000	0.000002
19.50	0.000000	0.000002
20.00	0.000000	0.000001
20.50	0.000000	0.000001
21.00	0.000000	0.000000
21.50	0.000000	0.000000
22.00	0.000000	0.000000
22.50	0.000000	0.000000
23.00	0.000000	0.000000
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.289	1.516	1.307	1.099	1.294
20%	2.231	2.551	2.300	1.885	2.249
10%	2.789	3.178	2.895	2.355	2.827
5%	3.283	3.712	3.426	2.767	3.343
1%	4.332	4.760	4.493	3.518	4.401

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.507	2.997	2.556	2.121	2.517
20%	4.278	4.979	4.440	3.568	4.326
10%	5.330	6.156	5.602	4.433	5.427
5%	6.275	7.171	6.647	5.206	6.426
1%	8.315	9.152	8.776	6.755	8.482

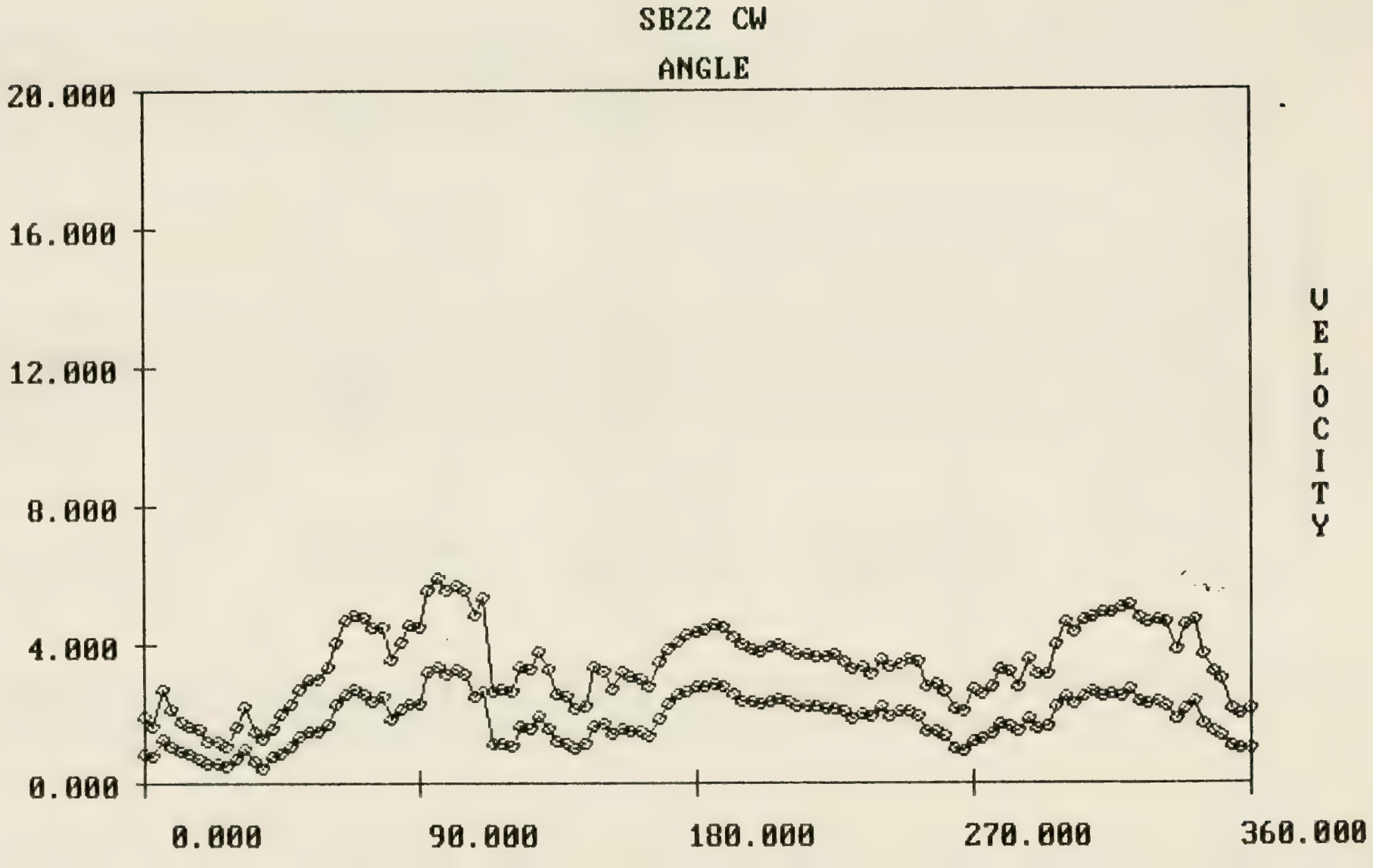
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.884	3.390	2.924	2.459	2.895
20%	4.990	5.707	5.144	4.216	5.031
10%	6.238	7.109	6.477	5.268	6.323
5%	7.345	8.304	7.664	6.189	7.479
1%	9.690	10.648	10.050	7.871	9.845

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.608	6.703	5.718	4.744	5.630
20%	9.571	11.137	9.932	7.982	9.677
10%	11.924	13.772	12.531	9.915	12.141
5%	14.036	16.042	14.868	11.646	14.374
1%	18.601	20.471	19.632	15.110	18.975

\nb17\sn22


SB22 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.888870	0.966674
1.00	0.692731	0.886579
1.50	0.499701	0.783272
2.00	0.336743	0.672761
2.50	0.213016	0.563968
3.00	0.127136	0.462244
3.50	0.071889	0.370955
4.00	0.038631	0.291914
4.50	0.019795	0.225617
5.00	0.009731	0.171539
5.50	0.004643	0.128480
6.00	0.002193	0.094904
6.50	0.001054	0.069192
7.00	0.000530	0.049815
7.50	0.000284	0.035427
8.00	0.000162	0.024891
8.50	0.000097	0.017283
9.00	0.000059	0.011866
9.50	0.000036	0.008064
10.00	0.000022	0.005433
10.50	0.000013	0.003638
11.00	0.000008	0.002429
11.50	0.000005	0.001624
12.00	0.000003	0.001093
12.50	0.000002	0.000744
13.00	0.000001	0.000515
13.50	0.000000	0.000364
14.00	0.000000	0.000262
14.50	0.000000	0.000193
15.00	0.000000	0.000145
15.50	0.000000	0.000110
16.00	0.000000	0.000085
16.50	0.000000	0.000066
17.00	0.000000	0.000051
17.50	0.000000	0.000040
18.00	0.000000	0.000031
18.50	0.000000	0.000024
19.00	0.000000	0.000019
19.50	0.000000	0.000015
20.00	0.000000	0.000011
20.50	0.000000	0.000009
21.00	0.000000	0.000007
21.50	0.000000	0.000005
22.00	0.000000	0.000004
22.50	0.000000	0.000003
23.00	0.000000	0.000002
23.50	0.000000	0.000002
24.00	0.000000	0.000001
24.50	0.000000	0.000001
25.00	0.000000	0.000001

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.516	1.730	1.546	1.280	1.499
20%	2.584	2.891	2.683	2.166	2.576
10%	3.240	3.584	3.353	2.700	3.246
5%	3.816	4.200	3.929	3.159	3.829
1%	5.030	5.365	5.083	4.045	4.987

Vguat (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.835	3.266	2.903	2.361	2.814
20%	4.737	5.365	4.926	3.893	4.737
10%	5.895	6.633	6.155	4.822	5.924
5%	6.947	7.743	7.245	5.640	6.995
1%	9.308	9.868	9.429	7.322	9.245

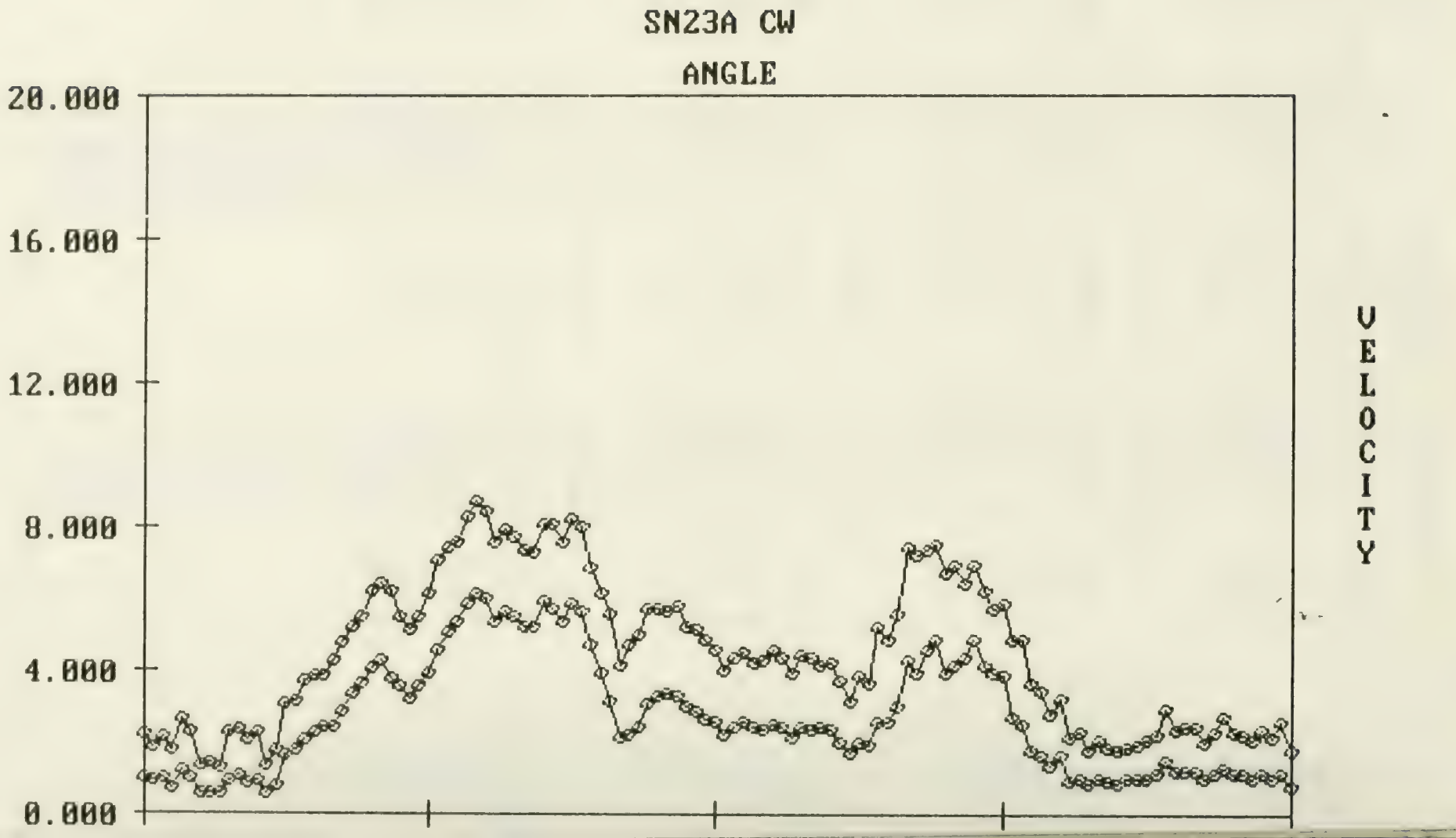
Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.390	3.870	3.458	2.864	3.354
20%	5.779	6.466	6.001	4.846	5.762
10%	7.247	8.016	7.501	6.039	7.260
5%	8.535	9.396	8.789	7.067	8.565
1%	11.251	12.002	11.370	9.048	11.155

Vguat (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.341	7.305	6.495	5.281	6.296
20%	10.597	12.001	11.019	8.708	10.596
10%	13.187	14.838	13.768	10.786	13.252
5%	15.540	17.321	16.208	12.617	15.648
1%	20.820	22.073	21.093	16.378	20.681

2


SN23A CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

elocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.891206	0.970586
1.00	0.677608	0.891493
1.50	0.488880	0.782300
2.00	0.360315	0.664280
2.50	0.273716	0.553256
3.00	0.210854	0.457551
3.50	0.163174	0.379031
4.00	0.126413	0.315739
4.50	0.097830	0.264484
5.00	0.075491	0.222372
5.50	0.058004	0.187272
6.00	0.044339	0.157734
6.50	0.033715	0.132749
7.00	0.025516	0.111575
7.50	0.019246	0.093627
8.00	0.014500	0.078423
8.50	0.010940	0.065560
9.00	0.008292	0.054694
9.50	0.006334	0.045535
10.00	0.004890	0.037833
10.50	0.003825	0.031373
11.00	0.003035	0.025972
11.50	0.002443	0.021469
12.00	0.001995	0.017727
12.50	0.001649	0.014627
13.00	0.001377	0.012066
13.50	0.001159	0.009957
14.00	0.000982	0.008224
14.50	0.000835	0.006802
15.00	0.000712	0.005638
15.50	0.000607	0.004687
16.00	0.000518	0.003908
16.50	0.000442	0.003272
17.00	0.000376	0.002751
17.50	0.000319	0.002323
18.00	0.000270	0.001972
18.50	0.000228	0.001682
19.00	0.000192	0.001441
19.50	0.000162	0.001241
20.00	0.000135	0.001073
20.50	0.000113	0.000932
21.00	0.000094	0.000812
21.50	0.000078	0.000710
22.00	0.000065	0.000622
22.50	0.000053	0.000546
23.00	0.000044	0.000481
23.50	0.000036	0.000423
24.00	0.000029	0.000373
24.50	0.000024	0.000329
25.00	0.000020	0.000290

17\sn23A

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.473	1.506	1.491	1.406	1.471
20%	3.267	3.129	3.158	2.933	3.114
10%	4.790	4.539	4.508	4.078	4.462
5%	6.381	5.866	5.851	5.149	5.793
1%	10.616	8.459	8.548	7.231	8.677

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.776	2.912	2.824	2.574	2.778
20%	5.545	5.417	5.375	4.958	5.319
10%	7.804	7.487	7.367	6.686	7.322
5%	10.066	9.430	9.290	8.287	9.256
1%	15.659	13.424	13.321	11.483	13.490

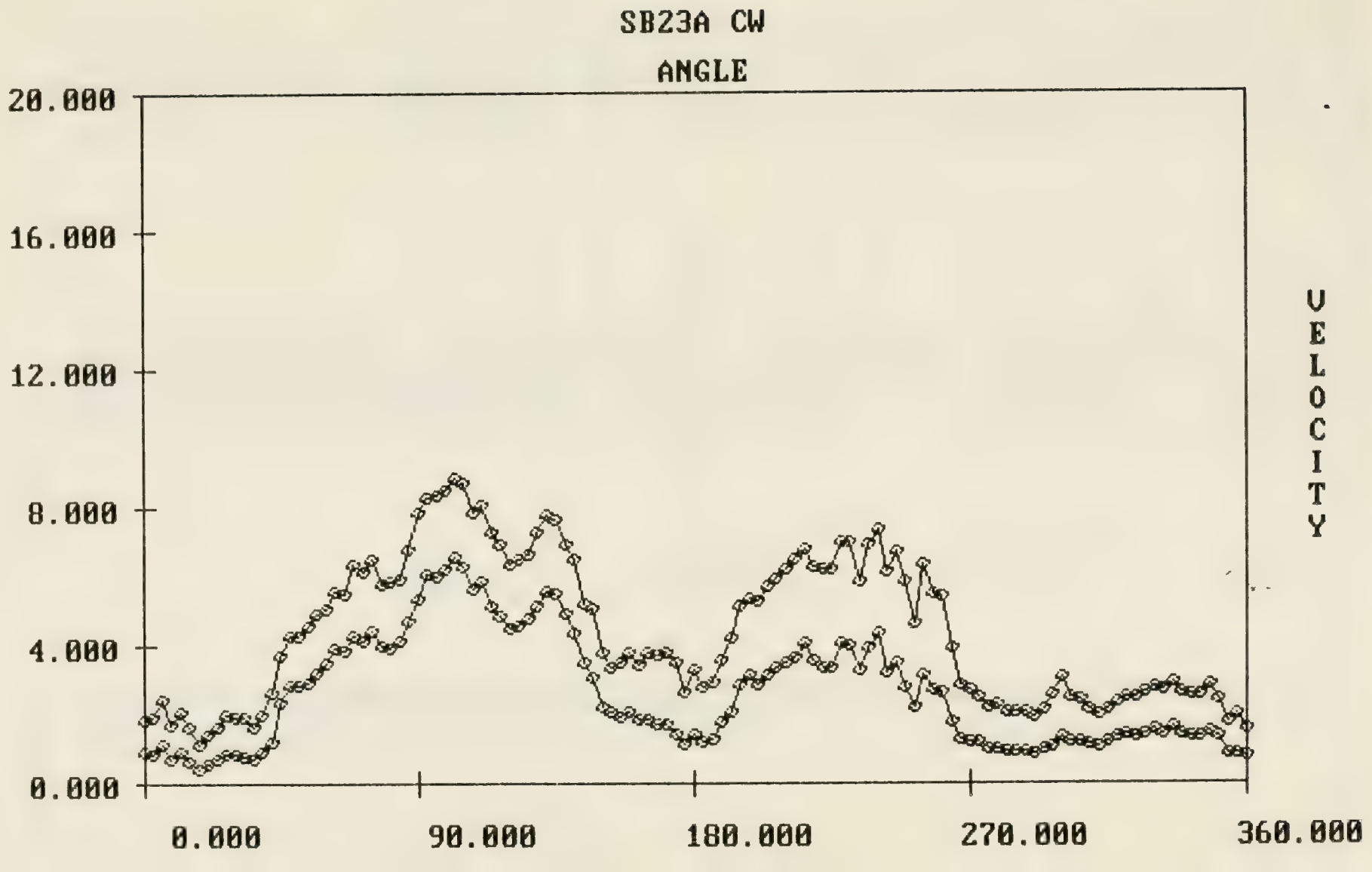
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.295	3.369	3.336	3.145	3.290
20%	7.307	6.999	7.064	6.562	6.965
10%	10.716	10.154	10.083	9.122	9.981
5%	14.274	13.123	13.088	11.517	12.958
1%	23.746	18.922	19.121	16.174	19.411

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.209	6.515	6.317	5.758	6.215
20%	12.404	12.117	12.024	11.091	11.898
10%	17.456	16.747	16.479	14.956	16.380
5%	22.517	21.094	20.780	18.537	20.706
1%	35.028	30.028	29.798	25.687	30.176

\nb17\sn23A


SB23A CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.883355	0.968798
1.00	0.662199	0.887217
1.50	0.464667	0.775927
2.00	0.328956	0.655618
2.50	0.242213	0.541580
3.00	0.183120	0.442495
3.50	0.138974	0.361276
4.00	0.104501	0.296912
4.50	0.077579	0.246441
5.00	0.056937	0.206497
5.50	0.041446	0.174193
6.00	0.030043	0.147420
6.50	0.021782	0.124785
7.00	0.015867	0.105406
7.50	0.011665	0.088728
8.00	0.008690	0.074372
8.50	0.006581	0.062056
9.00	0.005076	0.051545
9.50	0.003990	0.042629
10.00	0.003193	0.035114
10.50	0.002596	0.028821
11.00	0.002138	0.023585
11.50	0.001779	0.019254
12.00	0.001491	0.015691
12.50	0.001255	0.012775
13.00	0.001059	0.010399
13.50	0.000894	0.008469
14.00	0.000755	0.006908
14.50	0.000636	0.005646
15.00	0.000534	0.004628
15.50	0.000448	0.003807
16.00	0.000374	0.003145
16.50	0.000311	0.002610
17.00	0.000258	0.002176
17.50	0.000213	0.001824
18.00	0.000175	0.001536
18.50	0.000144	0.001300
19.00	0.000117	0.001105
19.50	0.000095	0.000943
20.00	0.000077	0.000808
20.50	0.000062	0.000694
21.00	0.000050	0.000598
21.50	0.000040	0.000516
22.00	0.000032	0.000446
22.50	0.000025	0.000386
23.00	0.000020	0.000334
23.50	0.000016	0.000290
24.00	0.000012	0.000251
24.50	0.000010	0.000217
25.00	0.000007	0.000188

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Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.426	1.442	1.456	1.308	1.411
20%	3.123	2.634	2.927	2.771	2.857
10%	4.532	3.865	4.176	3.805	4.084
5%	5.915	5.069	5.275	4.692	5.224
1%	10.082	7.472	7.420	6.437	7.780

Vgust (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.732	2.820	2.787	2.470	2.710
20%	5.506	4.875	5.182	4.902	5.101
10%	7.890	6.934	7.166	6.701	7.162
5%	10.075	9.077	8.995	8.255	9.087
1%	15.153	13.249	12.588	11.237	13.103

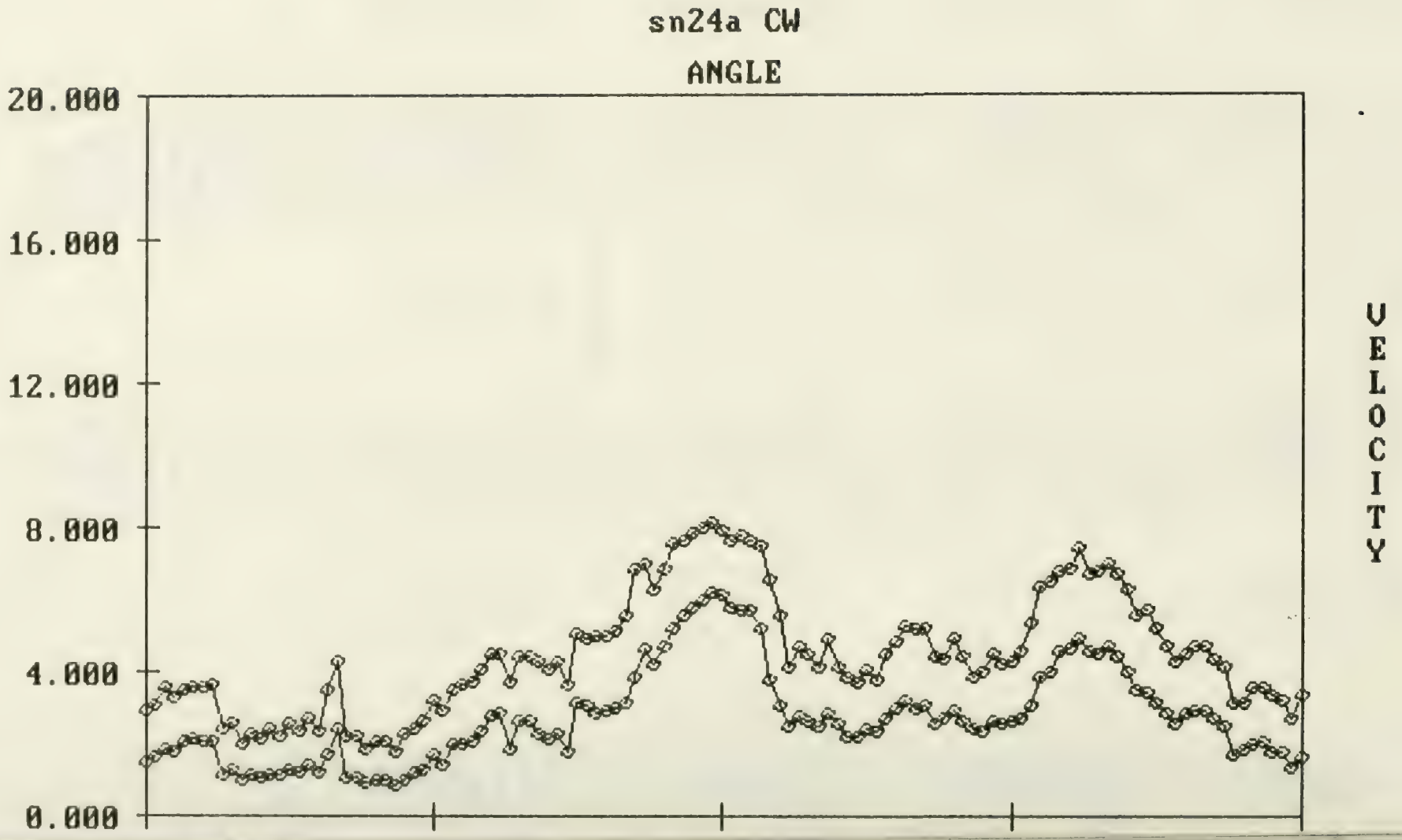
Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.191	3.225	3.257	2.927	3.155
20%	6.987	5.891	6.549	6.199	6.391
10%	10.138	8.645	9.341	8.512	9.135
5%	13.232	11.339	11.799	10.495	11.686
1%	22.552	16.715	16.598	14.400	17.403

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.112	6.308	6.234	5.526	6.062
20%	12.316	10.906	11.591	10.966	11.410
10%	17.649	15.511	16.029	14.990	16.021
5%	22.538	20.305	20.121	18.467	20.326
1%	33.897	29.638	28.159	25.136	29.311

7\sb23A


sn24a CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.941943	0.980903
1.00	0.817997	0.930169
1.50	0.685936	0.858633
2.00	0.562170	0.777346
2.50	0.450456	0.694002
3.00	0.353429	0.612746
3.50	0.272228	0.535634
4.00	0.206436	0.463805
4.50	0.154573	0.397965
5.00	0.114590	0.338515
5.50	0.084266	0.285581
6.00	0.061520	0.239052
6.50	0.044581	0.198635
7.00	0.032035	0.163908
7.50	0.022799	0.134370
8.00	0.016050	0.109474
8.50	0.011167	0.088668
9.00	0.007674	0.071410
9.50	0.005209	0.057195
10.00	0.003494	0.045559
10.50	0.002318	0.036091
11.00	0.001524	0.028431
11.50	0.000994	0.022268
12.00	0.000645	0.017339
12.50	0.000417	0.013420
13.00	0.000270	0.010322
13.50	0.000175	0.007890
14.00	0.000114	0.005993
14.50	0.000075	0.004524
15.00	0.000049	0.003394
15.50	0.000033	0.002530
16.00	0.000022	0.001876
16.50	0.000015	0.001383
17.00	0.000010	0.001014
17.50	0.000007	0.000740
18.00	0.000005	0.000538
18.50	0.000003	0.000390
19.00	0.000002	0.000281
19.50	0.000001	0.000203
20.00	0.000001	0.000146
20.50	0.000001	0.000105
21.00	0.000000	0.000075
21.50	0.000000	0.000054
22.00	0.000000	0.000038
22.50	0.000000	0.000028
23.00	0.000000	0.000020
23.50	0.000000	0.000014
24.00	0.000000	0.000010
24.50	0.000000	0.000007
25.00	0.000000	0.000005

ta

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.250	2.748	2.270	1.931	2.278
20%	3.955	4.761	4.166	3.386	4.062
10%	5.014	6.030	5.416	4.310	5.241
5%	5.990	7.203	6.601	5.163	6.340
1%	8.054	9.487	9.100	6.972	8.667

Vgust (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.707	4.483	3.754	3.183	3.748
20%	6.352	7.526	6.632	5.423	6.483
10%	7.950	9.387	8.481	6.807	8.228
5%	9.386	11.013	10.184	8.035	9.809
1%	12.329	14.211	13.683	10.572	13.066

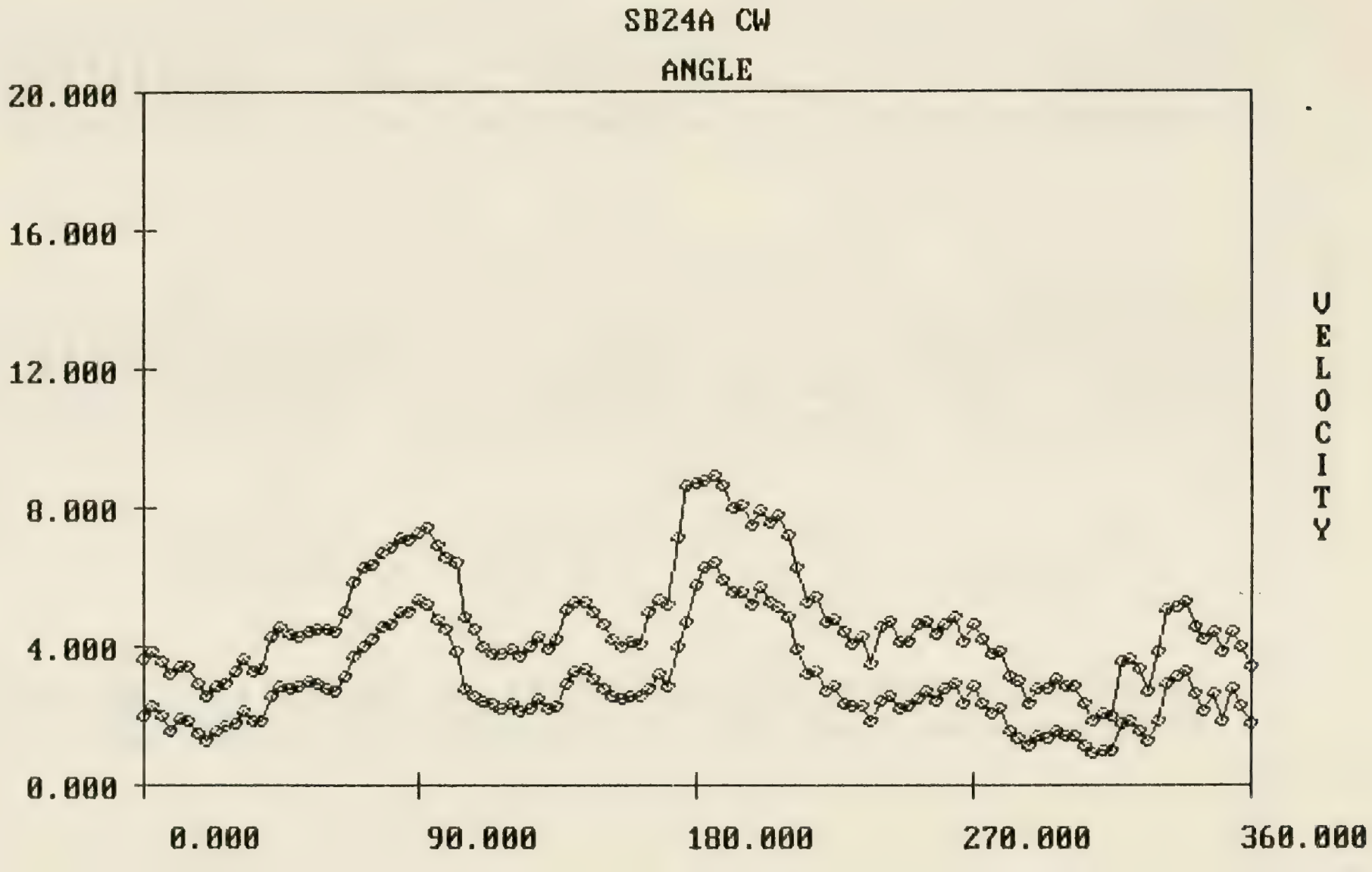
Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.032	6.147	5.079	4.319	5.096
20%	8.847	10.650	9.318	7.575	9.087
10%	11.216	13.488	12.114	9.641	11.723
5%	13.400	16.112	14.767	11.550	14.182
1%	18.017	21.222	20.357	15.595	19.388

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.293	10.028	8.396	7.120	8.384
20%	14.209	16.835	14.835	12.130	14.502
10%	17.785	20.998	18.971	15.227	18.405
5%	20.995	24.636	22.781	17.973	21.942
1%	27.579	31.789	30.608	23.650	29.228

sn24a


SB24A CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.941956	0.982545
1.00	0.790207	0.932284
1.50	0.607108	0.854685
2.00	0.443000	0.759014
2.50	0.314757	0.655577
3.00	0.220696	0.553253
3.50	0.153862	0.458217
4.00	0.107198	0.373881
4.50	0.074964	0.301491
5.00	0.052826	0.240881
5.50	0.037621	0.191081
6.00	0.027106	0.150752
6.50	0.019743	0.118457
7.00	0.014507	0.092819
7.50	0.010721	0.072602
8.00	0.007946	0.056743
8.50	0.005891	0.044352
9.00	0.004360	0.034697
9.50	0.003217	0.027186
10.00	0.002365	0.021345
10.50	0.001731	0.016801
11.00	0.001261	0.013258
11.50	0.000915	0.010489
12.00	0.000661	0.008318
12.50	0.000476	0.006609
13.00	0.000341	0.005259
13.50	0.000244	0.004188
14.00	0.000174	0.003337
14.50	0.000123	0.002659
15.00	0.000087	0.002118
15.50	0.000062	0.001685
16.00	0.000044	0.001339
16.50	0.000031	0.001063
17.00	0.000022	0.000842
17.50	0.000015	0.000666
18.00	0.000011	0.000526
18.50	0.000007	0.000415
19.00	0.000005	0.000326
19.50	0.000004	0.000256
20.00	0.000002	0.000201
20.50	0.000002	0.000158
21.00	0.000001	0.000123
21.50	0.000001	0.000096
22.00	0.000001	0.000075
22.50	0.000000	0.000058
23.00	0.000000	0.000045
23.50	0.000000	0.000035
24.00	0.000000	0.000027
24.50	0.000000	0.000021
25.00	0.000000	0.000016

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.862	1.909	1.883	1.647	1.826
20%	3.314	3.197	3.289	2.846	3.155
10%	4.358	4.135	4.310	3.657	4.112
5%	5.417	5.113	5.335	4.448	5.093
1%	8.002	8.009	7.807	6.464	7.630

Vgust (m/s)

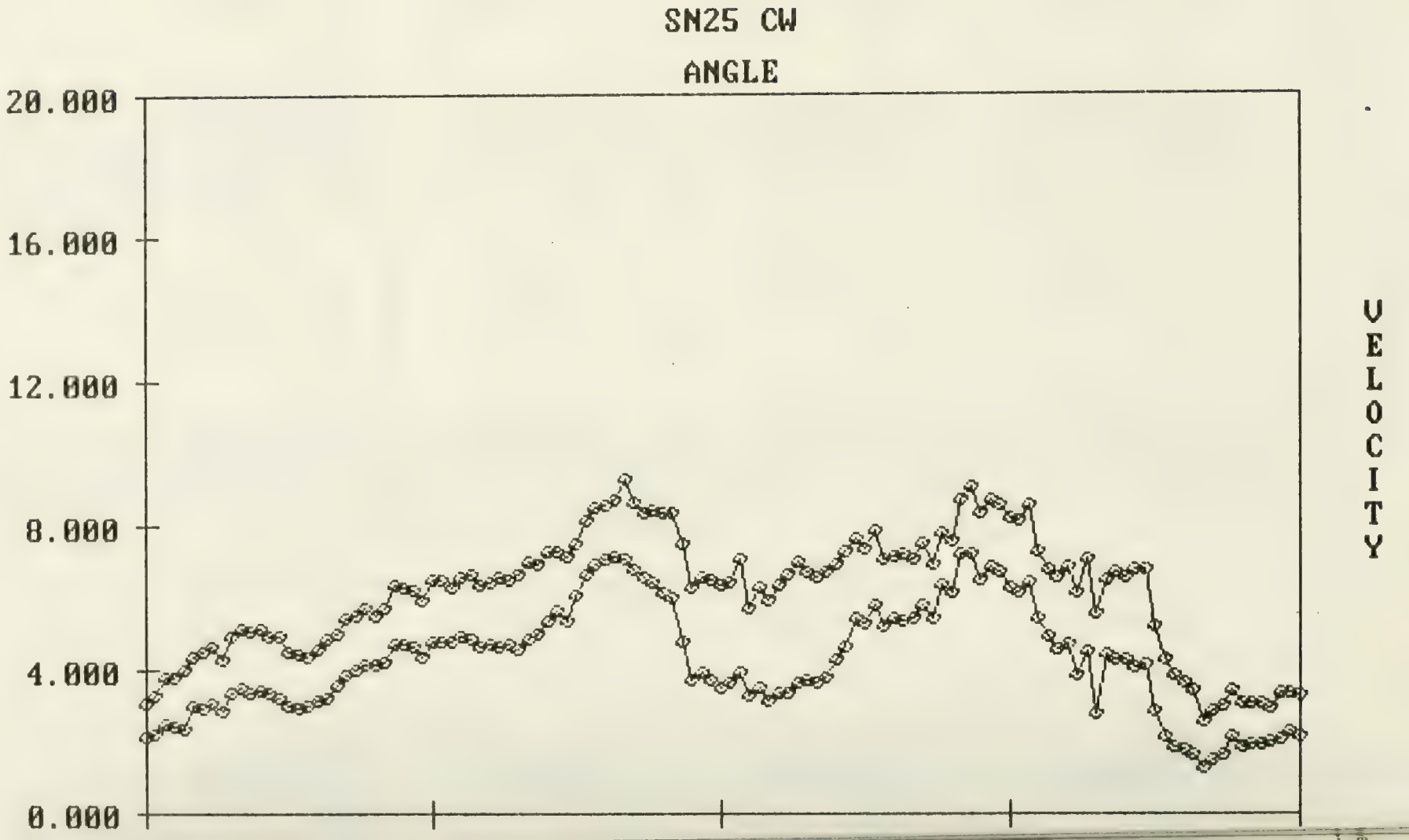
bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.324	3.506	3.380	2.914	3.280
20%	5.609	5.595	5.614	4.832	5.410
10%	7.180	7.024	7.127	6.061	6.860
5%	8.694	8.468	8.569	7.224	8.272
1%	12.178	12.229	11.808	9.815	11.613

Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.166	4.271	4.212	3.684	4.085
20%	7.414	7.150	7.356	6.366	7.057
10%	9.749	9.249	9.642	8.180	9.198
5%	12.118	11.438	11.934	9.950	11.393
1%	17.900	17.915	17.464	14.460	17.068

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.436	7.842	7.561	6.518	7.338
20%	12.546	12.515	12.558	10.808	12.103
10%	16.060	15.711	15.944	13.557	15.345
5%	19.449	18.941	19.168	16.159	18.504
1%	27.241	27.354	26.414	21.956	25.977


SN25 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

elocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.974284	0.989760
1.00	0.904711	0.960890
1.50	0.808655	0.916047
2.00	0.705319	0.859139
2.50	0.607638	0.794632
3.00	0.520863	0.726768
3.50	0.445376	0.658997
4.00	0.379765	0.593728
4.50	0.322509	0.532360
5.00	0.272472	0.475502
5.50	0.228852	0.423246
6.00	0.191033	0.375417
6.50	0.158475	0.331741
7.00	0.130671	0.291939
7.50	0.107119	0.255762
8.00	0.087332	0.223000
8.50	0.070833	0.193465
9.00	0.057175	0.166982
9.50	0.045939	0.143380
10.00	0.036752	0.122481
10.50	0.029278	0.104099
11.00	0.023228	0.088040
11.50	0.018354	0.074106
12.00	0.014445	0.062096
12.50	0.011323	0.051810
13.00	0.008841	0.043054
13.50	0.006877	0.035645
14.00	0.005330	0.029408
14.50	0.004116	0.024186
15.00	0.003168	0.019833
15.50	0.002431	0.016221
16.00	0.001860	0.013236
16.50	0.001419	0.010777
17.00	0.001080	0.008759
17.50	0.000821	0.007107
18.00	0.000622	0.005758
18.50	0.000471	0.004660
19.00	0.000357	0.003768
19.50	0.000269	0.003044
20.00	0.000204	0.002457
20.50	0.000154	0.001983
21.00	0.000116	0.001601
21.50	0.000088	0.001292
22.00	0.000066	0.001043
22.50	0.000050	0.000843
23.00	0.000038	0.000681
23.50	0.000029	0.000551
24.00	0.000022	0.000447
24.50	0.000016	0.000363
25.00	0.000013	0.000295

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.109	3.515	3.109	2.860	3.138
20%	5.887	6.487	5.847	5.286	5.881
10%	7.755	8.292	7.740	6.852	7.680
5%	9.473	9.896	9.508	8.245	9.319
1%	13.089	13.198	13.307	10.991	12.767

Vguat (m/s)

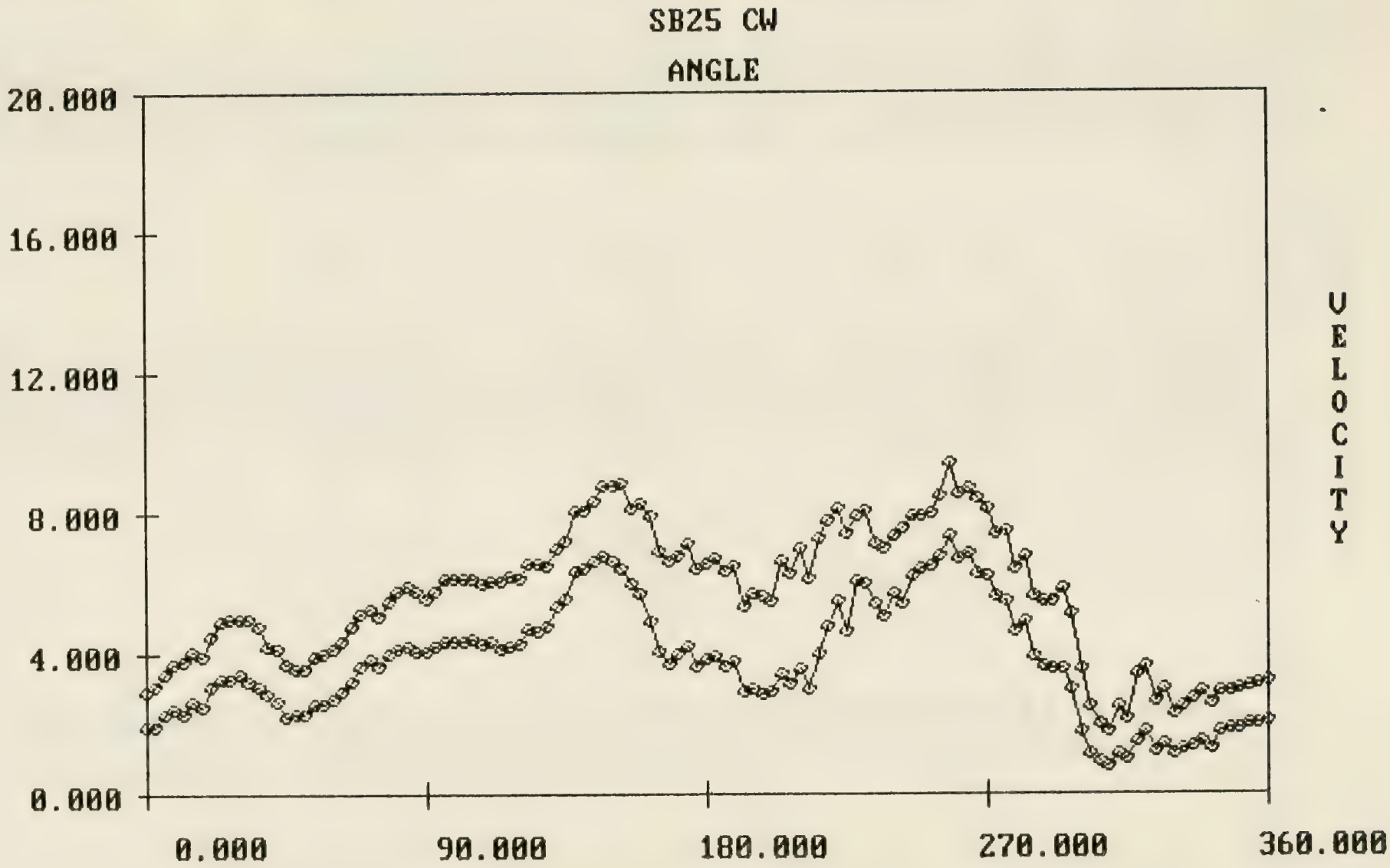
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.752	5.416	4.778	4.278	4.785
20%	8.367	9.332	8.434	7.402	8.389
10%	10.641	11.568	10.806	9.307	10.628
5%	12.693	13.477	12.927	10.955	12.603
1%	17.095	17.291	17.336	14.238	16.692

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.955	7.863	6.955	6.398	7.020
20%	13.168	14.511	13.079	11.824	13.156
10%	17.348	18.549	17.313	15.326	17.179
5%	21.189	22.137	21.269	18.444	20.847
1%	29.280	29.523	29.767	24.587	28.558

Vguat (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.630	12.115	10.687	9.570	10.703
20%	18.717	20.876	18.866	16.557	18.766
10%	23.804	25.878	24.171	20.820	23.773
5%	28.394	30.147	28.916	24.506	28.193
1%	38.240	38.678	38.779	31.848	37.340


SB25 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.954432	0.985811
1.00	0.837040	0.944218
1.50	0.703040	0.880018
2.00	0.587043	0.801623
2.50	0.494205	0.718114
3.00	0.419489	0.636772
3.50	0.357637	0.561995
4.00	0.305127	0.495520
4.50	0.259862	0.437284
5.00	0.220605	0.386335
5.50	0.186549	0.341488
6.00	0.157079	0.301675
6.50	0.131663	0.266066
7.00	0.109828	0.234065
7.50	0.091148	0.205257
8.00	0.075242	0.179341
8.50	0.061767	0.156086
9.00	0.050415	0.135296
9.50	0.040912	0.116794
10.00	0.033006	0.100408
10.50	0.026473	0.085971
11.00	0.021111	0.073317
11.50	0.016740	0.062282
12.00	0.013201	0.052708
12.50	0.010353	0.044440
13.00	0.008077	0.037335
13.50	0.006269	0.031255
14.00	0.004842	0.026076
14.50	0.003721	0.021682
15.00	0.002846	0.017970
15.50	0.002167	0.014846
16.00	0.001643	0.012228
16.50	0.001240	0.010041
17.00	0.000932	0.008222
17.50	0.000698	0.006713
18.00	0.000520	0.005467
18.50	0.000386	0.004440
19.00	0.000286	0.003598
19.50	0.000211	0.002908
20.00	0.000155	0.002346
20.50	0.000114	0.001889
21.00	0.000083	0.001517
21.50	0.000061	0.001217
22.00	0.000044	0.000975
22.50	0.000032	0.000780
23.00	0.000023	0.000623
23.50	0.000017	0.000497
24.00	0.000012	0.000396
24.50	0.000009	0.000316
25.00	0.000006	0.000251

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.480	2.577	2.444	2.393	2.469
20%	5.412	5.692	5.177	4.946	5.303
10%	7.448	7.728	7.225	6.656	7.263
5%	9.263	9.535	9.156	8.136	9.022
1%	12.826	13.087	13.066	10.967	12.578

Vgust (m/s)

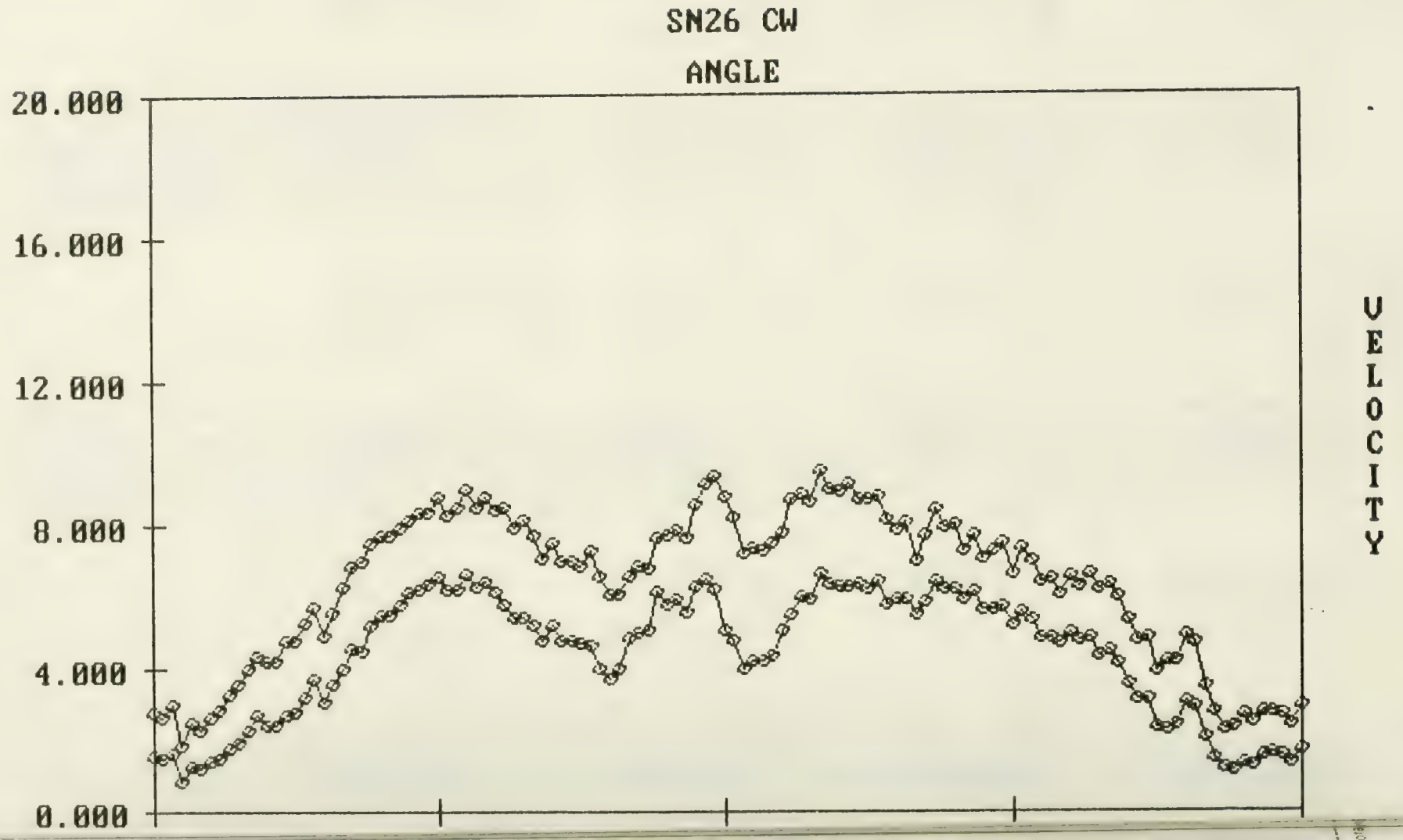
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.969	4.240	3.959	3.715	3.966
20%	7.755	8.177	7.537	6.986	7.601
10%	10.258	10.688	10.067	9.055	10.014
5%	12.465	12.866	12.367	10.849	12.164
1%	16.932	17.186	17.054	14.318	16.511

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.547	5.764	5.467	5.353	5.523
20%	12.106	12.732	11.582	11.063	11.861
10%	16.661	17.286	16.163	14.889	16.247
5%	20.722	21.330	20.482	18.199	20.181
1%	28.691	29.276	29.227	24.534	28.135

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.877	9.486	8.857	8.310	8.872
20%	17.346	18.292	16.860	15.626	17.004
10%	22.946	23.908	22.520	20.255	22.401
5%	27.883	28.780	27.665	24.269	27.210
1%	37.877	38.445	38.148	32.029	36.935


SN26 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.965752	0.987652
1.00	0.885057	0.953900
1.50	0.790995	0.903940
2.00	0.701742	0.844028
2.50	0.620590	0.779743
3.00	0.545699	0.715020
3.50	0.475963	0.652075
4.00	0.411478	0.591871
4.50	0.352600	0.534687
5.00	0.299513	0.480577
5.50	0.252199	0.429594
6.00	0.210502	0.381853
6.50	0.174167	0.337495
7.00	0.142866	0.296633
7.50	0.116207	0.259317
8.00	0.093757	0.225523
8.50	0.075058	0.195161
9.00	0.059647	0.168084
9.50	0.047076	0.144104
10.00	0.036917	0.123006
10.50	0.028782	0.104562
11.00	0.022319	0.088534
11.50	0.017225	0.074685
12.00	0.013235	0.062784
12.50	0.010131	0.052611
13.00	0.007729	0.043956
13.50	0.005879	0.036627
14.00	0.004462	0.030447
14.50	0.003380	0.025257
15.00	0.002557	0.020913
15.50	0.001934	0.017289
16.00	0.001462	0.014274
16.50	0.001106	0.011773
17.00	0.000838	0.009703
17.50	0.000636	0.007993
18.00	0.000484	0.006582
18.50	0.000369	0.005421
19.00	0.000283	0.004465
19.50	0.000217	0.003680
20.00	0.000167	0.003035
20.50	0.000129	0.002506
21.00	0.000101	0.002072
21.50	0.000078	0.001716
22.00	0.000061	0.001423
22.50	0.000048	0.001183
23.00	0.000038	0.000985
23.50	0.000029	0.000823
24.00	0.000023	0.000689
24.50	0.000018	0.000578
25.00	0.000014	0.000486

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.329	3.660	3.302	3.058	3.328
20%	6.250	6.592	6.206	5.539	6.145
10%	8.065	8.320	7.983	7.015	7.861
5%	9.711	9.841	9.555	8.311	9.384
1%	13.169	12.998	12.689	10.825	12.527

Vgust (m/s)

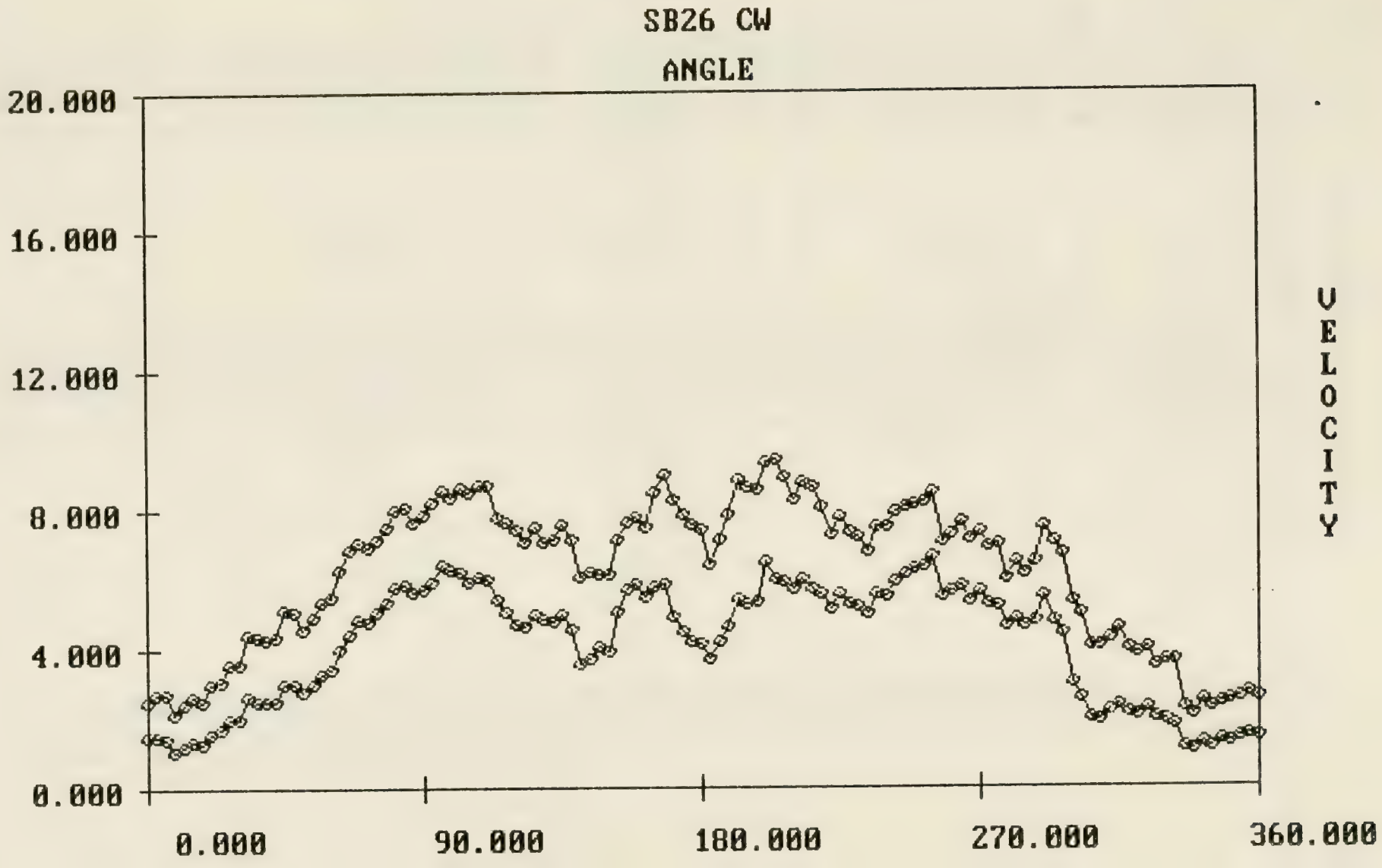
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.830	5.299	4.842	4.369	4.821
20%	8.564	8.998	8.577	7.535	8.420
10%	10.949	11.226	10.865	9.447	10.642
5%	13.167	13.230	12.889	11.137	12.651
1%	18.082	17.561	16.943	14.503	16.928

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.446	8.187	7.387	6.840	7.444
20%	13.980	14.745	13.883	12.390	13.745
10%	18.041	18.612	17.858	15.693	17.584
5%	21.724	22.014	21.375	18.591	20.991
1%	29.459	29.075	28.384	24.216	28.023

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.804	11.854	10.831	9.773	10.783
20%	19.157	20.129	19.186	16.855	18.836
10%	24.491	25.112	24.304	21.132	23.806
5%	29.453	29.595	28.831	24.913	28.299
1%	40.448	39.284	37.901	32.442	37.868


SB26 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.961719	0.986984
1.00	0.869529	0.951163
1.50	0.762325	0.898065
2.00	0.662398	0.834608
2.50	0.573887	0.767021
3.00	0.495750	0.699592
3.50	0.427027	0.634581
4.00	0.366690	0.572860
4.50	0.313486	0.514663
5.00	0.266306	0.460079
5.50	0.224407	0.409220
6.00	0.187358	0.362203
6.50	0.154893	0.319091
7.00	0.126779	0.279853
7.50	0.102750	0.244376
8.00	0.082488	0.212478
8.50	0.065626	0.183946
9.00	0.051773	0.158549
9.50	0.040526	0.136052
10.00	0.031499	0.116225
10.50	0.024326	0.098845
11.00	0.018681	0.083694
11.50	0.014275	0.070560
12.00	0.010862	0.059241
12.50	0.008236	0.049542
13.00	0.006227	0.041277
13.50	0.004697	0.034272
14.00	0.003538	0.028367
14.50	0.002662	0.023413
15.00	0.002002	0.019276
15.50	0.001506	0.015837
16.00	0.001134	0.012988
16.50	0.000855	0.010638
17.00	0.000645	0.008704
17.50	0.000489	0.007118
18.00	0.000371	0.005819
18.50	0.000282	0.004759
19.00	0.000215	0.003895
19.50	0.000165	0.003190
20.00	0.000127	0.002617
20.50	0.000098	0.002150
21.00	0.000075	0.001771
21.50	0.000058	0.001461
22.00	0.000045	0.001209
22.50	0.000035	0.001004
23.00	0.000027	0.000835
23.50	0.000021	0.000697
24.00	0.000017	0.000584
24.50	0.000013	0.000491
25.00	0.000010	0.000414

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.976	3.194	2.946	2.802	2.973
20%	5.968	6.246	5.855	5.302	5.829
10%	7.786	8.046	7.681	6.764	7.568
5%	9.374	9.569	9.258	7.998	9.079
1%	12.735	12.608	12.376	10.440	12.164

Vguat (m/s)

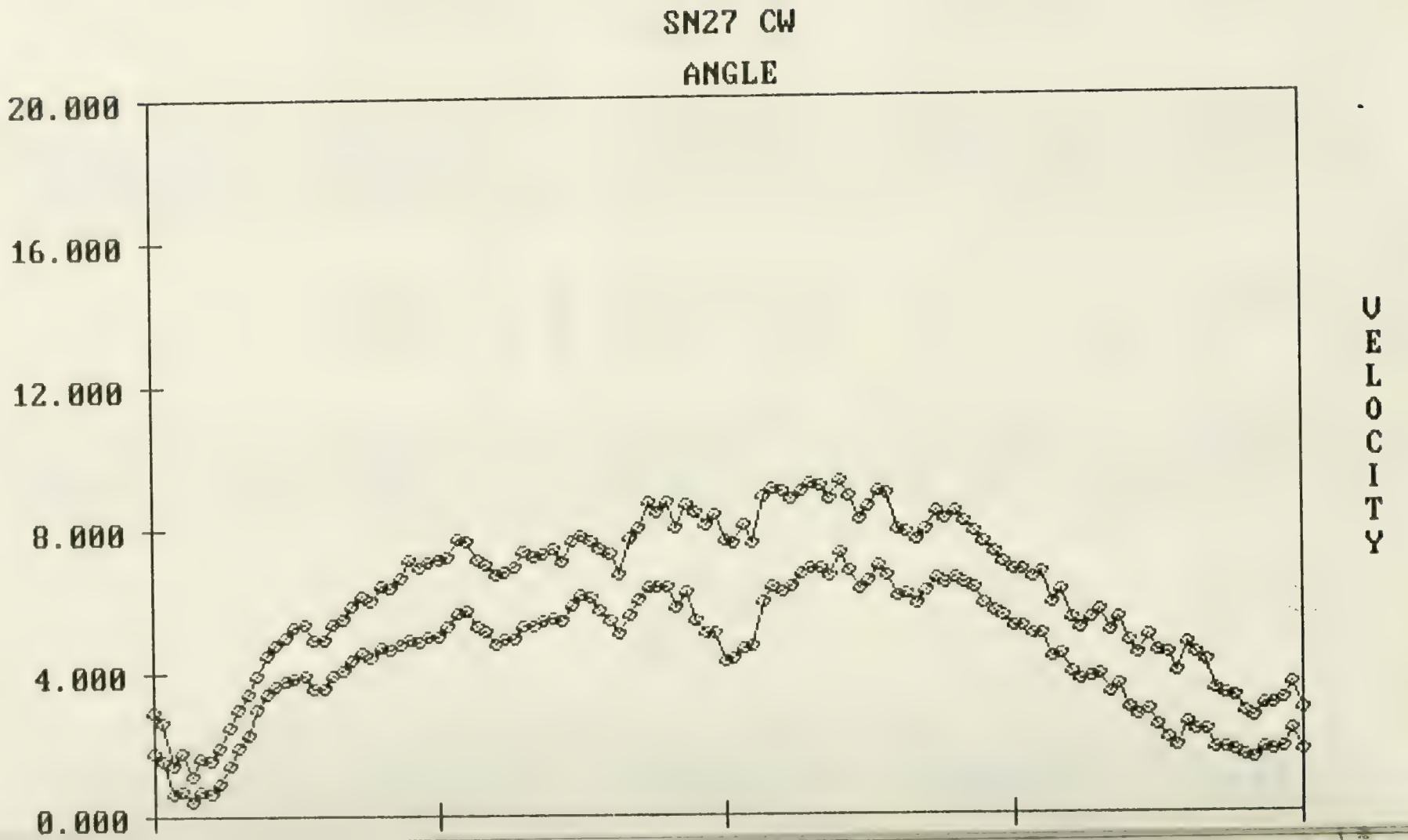
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.636	5.073	4.654	4.221	4.634
20%	8.375	8.803	8.348	7.376	8.219
10%	10.776	11.107	10.681	9.282	10.467
5%	12.939	13.137	12.737	10.928	12.476
1%	17.725	17.283	16.794	14.172	16.665

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	6.657	7.144	6.591	6.267	6.650
20%	13.350	13.973	13.097	11.860	13.040
10%	17.417	17.998	17.182	15.131	16.929
5%	20.969	21.404	20.709	17.890	20.309
1%	28.487	28.203	27.685	23.353	27.210

Vguat (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.370	11.348	10.410	9.442	10.367
20%	18.734	19.691	18.674	16.499	18.385
10%	24.104	24.847	23.894	20.764	23.414
5%	28.945	29.387	28.492	24.446	27.909
1%	39.650	38.662	37.567	31.701	37.278


SN27 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

elocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.957709	0.985295
1.00	0.882418	0.948251
1.50	0.794918	0.897914
2.00	0.702136	0.840219
2.50	0.612600	0.778199
3.00	0.530375	0.713954
3.50	0.456415	0.649388
4.00	0.390599	0.586139
4.50	0.332541	0.525444
5.00	0.281737	0.468145
5.50	0.237586	0.414762
6.00	0.199437	0.365582
6.50	0.166635	0.320723
7.00	0.138562	0.280166
7.50	0.114649	0.243787
8.00	0.094379	0.211382
8.50	0.077285	0.182691
9.00	0.062949	0.157418
9.50	0.050993	0.135256
10.00	0.041082	0.115896
10.50	0.032917	0.099042
11.00	0.026232	0.084415
11.50	0.020795	0.071758
12.00	0.016400	0.060838
12.50	0.012870	0.051443
13.00	0.010053	0.043383
13.50	0.007818	0.036488
14.00	0.006054	0.030609
14.50	0.004671	0.025610
15.00	0.003592	0.021372
15.50	0.002754	0.017791
16.00	0.002106	0.014775
16.50	0.001607	0.012241
17.00	0.001224	0.010120
17.50	0.000932	0.008349
18.00	0.000709	0.006875
18.50	0.000539	0.005651
19.00	0.000410	0.004638
19.50	0.000313	0.003801
20.00	0.000238	0.003112
20.50	0.000182	0.002545
21.00	0.000140	0.002080
21.50	0.000107	0.001699
22.00	0.000083	0.001388
22.50	0.000064	0.001134
23.00	0.000049	0.000926
23.50	0.000038	0.000757
24.00	0.000030	0.000620
24.50	0.000023	0.000508
25.00	0.000018	0.000416

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.210	3.430	3.196	2.987	3.205
20%	6.186	6.269	6.016	5.540	5.993
10%	8.206	8.161	7.918	7.180	7.861
5%	9.994	9.933	9.648	8.605	9.550
1%	13.611	13.645	13.071	11.362	13.012

Vgust (m/s)

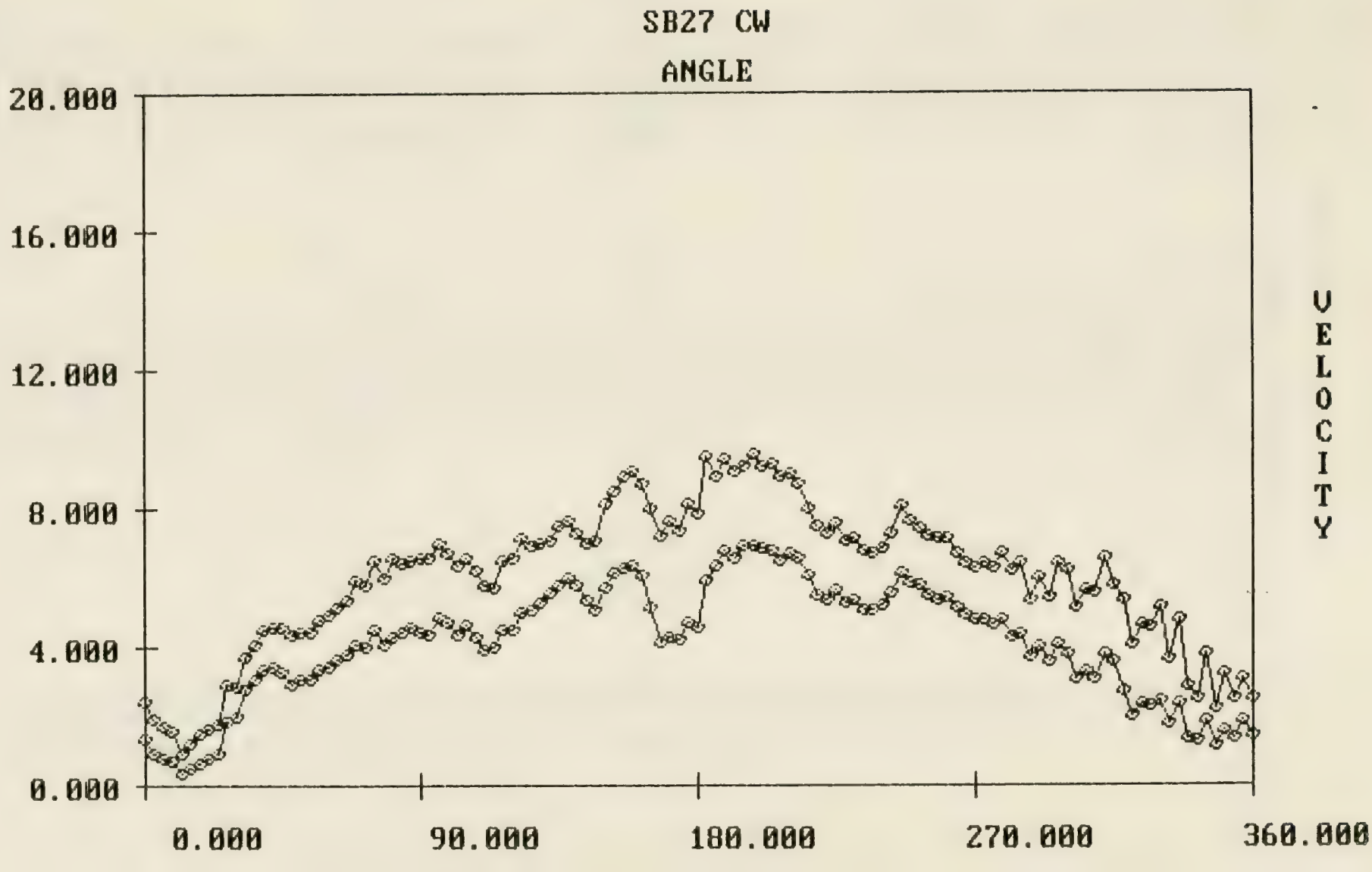
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.725	5.167	4.754	4.273	4.722
20%	8.368	8.663	8.310	7.429	8.198
10%	10.859	10.937	10.632	9.446	10.472
5%	13.149	13.121	12.766	11.247	12.590
1%	17.889	17.866	17.065	14.776	17.034

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.180	7.672	7.150	6.681	7.170
20%	13.837	14.022	13.456	12.393	13.405
10%	18.357	18.255	17.712	16.062	17.585
5%	22.356	22.220	21.582	19.248	21.363
1%	30.447	30.523	29.239	25.415	29.107

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.569	11.558	10.633	9.559	10.563
20%	18.719	19.378	18.589	16.618	18.339
10%	24.291	24.465	23.782	21.130	23.424
5%	29.415	29.352	28.557	25.159	28.162
1%	40.016	39.965	38.174	33.052	38.104


SB27 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
0.000
90.000
180.000
270.000
360.000
VELOCITY

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.951595	0.982872
1.00	0.869947	0.942159
1.50	0.781613	0.889968
2.00	0.691536	0.832374
2.50	0.603590	0.771925
3.00	0.520326	0.710084
3.50	0.443487	0.648037
4.00	0.374145	0.586854
4.50	0.312697	0.527454
5.00	0.259039	0.470578
5.50	0.212767	0.416803
6.00	0.173325	0.366558
6.50	0.140076	0.320138
7.00	0.112349	0.277711
7.50	0.089461	0.239329
8.00	0.070750	0.204949
8.50	0.055592	0.174445
9.00	0.043415	0.147623
9.50	0.033710	0.124241
10.00	0.026033	0.104026
10.50	0.020001	0.086682
11.00	0.015294	0.071910
11.50	0.011643	0.059412
12.00	0.008828	0.048904
12.50	0.006670	0.040120
13.00	0.005023	0.032816
13.50	0.003773	0.026771
14.00	0.002828	0.021789
14.50	0.002116	0.017699
15.00	0.001582	0.014352
15.50	0.001181	0.011622
16.00	0.000883	0.009400
16.50	0.000660	0.007597
17.00	0.000494	0.006136
17.50	0.000370	0.004953
18.00	0.000278	0.003998
18.50	0.000209	0.003227
19.00	0.000158	0.002605
19.50	0.000119	0.002104
20.00	0.000090	0.001701
20.50	0.000069	0.001376
21.00	0.000052	0.001114
21.50	0.000040	0.000903
22.00	0.000030	0.000733
22.50	0.000023	0.000596
23.00	0.000018	0.000485
23.50	0.000014	0.000395
24.00	0.000010	0.000323
24.50	0.000008	0.000264
25.00	0.000006	0.000217

Vmean (m/s)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.130	3.433	3.128	2.867	3.132
20%	5.766	6.020	5.723	5.133	5.662
10%	7.480	7.636	7.391	6.526	7.270
5%	9.040	9.130	8.894	7.765	8.730
1%	12.274	12.383	11.903	10.182	11.792

Vgust (m/s)

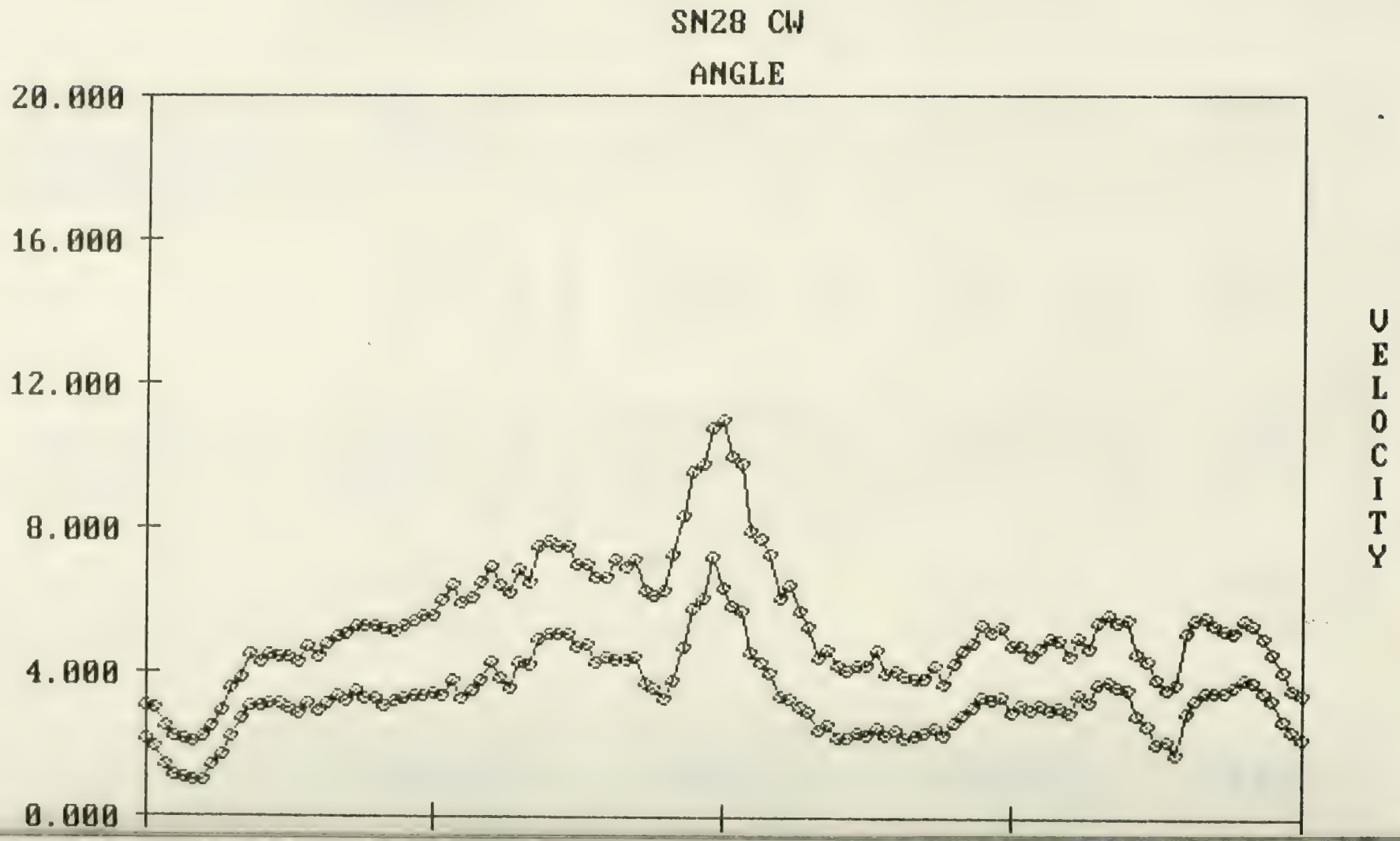
bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.740	5.315	4.780	4.210	4.741
20%	8.146	8.761	8.246	7.142	8.081
10%	10.281	10.788	10.362	8.901	10.116
5%	12.247	12.617	12.248	10.446	11.948
1%	16.503	16.655	16.040	13.556	15.865

Vmean (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.001	7.679	6.996	6.413	7.007
20%	12.898	13.466	12.802	11.483	12.665
10%	16.733	17.081	16.533	14.597	16.262
5%	20.222	20.423	19.895	17.370	19.528
1%	27.455	27.699	26.626	22.777	26.378

Vgust (mph)

bability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	10.603	11.890	10.693	9.417	10.606
20%	18.221	19.598	18.446	15.976	18.077
10%	22.998	24.131	23.180	19.910	22.629
5%	27.395	28.224	27.397	23.368	26.727
1%	36.917	37.257	35.881	30.323	35.489


SN28 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

locity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.963291	0.986461
1.00	0.871369	0.948997
1.50	0.749335	0.892041
2.00	0.615752	0.821009
2.50	0.484890	0.741209
3.00	0.367465	0.657234
3.50	0.269317	0.572856
4.00	0.191790	0.491131
4.50	0.133263	0.414447
5.00	0.090701	0.344521
5.50	0.060725	0.282395
6.00	0.040199	0.228488
6.50	0.026488	0.182701
7.00	0.017514	0.144557
7.50	0.011727	0.113329
8.00	0.008021	0.088164
8.50	0.005643	0.068172
9.00	0.004095	0.052492
9.50	0.003062	0.040332
10.00	0.002350	0.030994
10.50	0.001841	0.023878
11.00	0.001464	0.018488
11.50	0.001175	0.014420
12.00	0.000950	0.011352
12.50	0.000771	0.009033
13.00	0.000627	0.007271
13.50	0.000510	0.005922
14.00	0.000416	0.004878
14.50	0.000339	0.004060
15.00	0.000276	0.003410
15.50	0.000224	0.002886
16.00	0.000182	0.002458
16.50	0.000148	0.002104
17.00	0.000120	0.001809
17.50	0.000097	0.001559
18.00	0.000078	0.001347
18.50	0.000063	0.001165
19.00	0.000051	0.001009
19.50	0.000041	0.000875
20.00	0.000033	0.000759
20.50	0.000026	0.000659
21.00	0.000021	0.000572
21.50	0.000016	0.000496
22.00	0.000013	0.000431
22.50	0.000010	0.000373
23.00	0.000008	0.000324
23.50	0.000006	0.000281
24.00	0.000005	0.000243
24.50	0.000004	0.000211
25.00	0.000003	0.000182

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.431	2.819	2.538	2.067	2.442
20%	3.928	4.411	4.124	3.306	3.947
10%	4.884	5.354	5.100	4.030	4.891
5%	5.820	6.183	5.976	4.720	5.761
1%	8.585	7.938	7.861	6.125	7.733

Vgust (m/s)

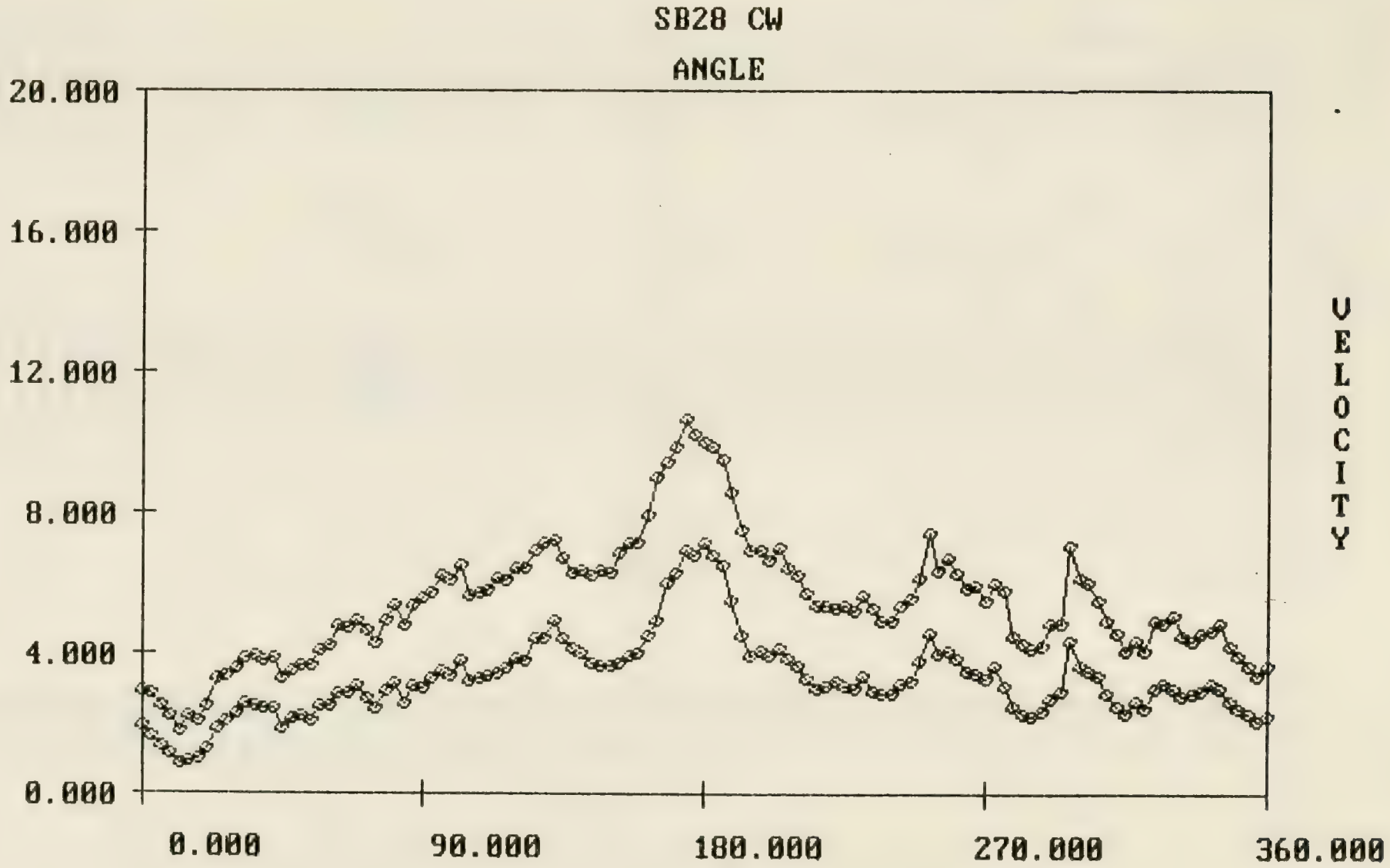
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.933	4.510	4.096	3.363	3.946
20%	6.304	6.969	6.578	5.313	6.311
10%	7.805	8.410	8.090	6.464	7.765
5%	9.291	9.696	9.458	7.502	9.102
1%	13.815	12.573	12.436	9.779	12.291

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.437	6.305	5.676	4.625	5.463
20%	8.786	9.867	9.225	7.394	8.829
10%	10.926	11.976	11.408	9.015	10.940
5%	13.019	13.831	13.368	10.558	12.888
1%	19.204	17.757	17.585	13.702	17.298

Vgust (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	8.797	10.090	9.162	7.522	8.826
20%	14.102	15.589	14.715	11.884	14.118
10%	17.459	18.813	18.098	14.460	17.369
5%	20.784	21.689	21.156	16.781	20.362
1%	30.903	28.124	27.820	21.875	27.495


SB28 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY
0.000
90.000
180.000
270.000
360.000

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.962643	0.986867
1.00	0.871452	0.950974
1.50	0.753082	0.897194
2.00	0.625018	0.831101
2.50	0.500114	0.757750
3.00	0.387549	0.681167
3.50	0.292201	0.604420
4.00	0.215327	0.529831
4.50	0.155774	0.459142
5.00	0.111101	0.393589
5.50	0.078430	0.333967
6.00	0.054995	0.280683
6.50	0.038423	0.233823
7.00	0.026821	0.193214
7.50	0.018750	0.158493
8.00	0.013156	0.129165
8.50	0.009283	0.104662
9.00	0.006598	0.084385
9.50	0.004729	0.067748
10.00	0.003421	0.054195
10.50	0.002499	0.043225
11.00	0.001842	0.034393
11.50	0.001370	0.027315
12.00	0.001027	0.021666
12.50	0.000775	0.017172
13.00	0.000588	0.013608
13.50	0.000447	0.010787
14.00	0.000342	0.008559
14.50	0.000261	0.006802
15.00	0.000200	0.005417
15.50	0.000153	0.004325
16.00	0.000117	0.003463
16.50	0.000090	0.002783
17.00	0.000068	0.002245
17.50	0.000052	0.001818
18.00	0.000040	0.001478
18.50	0.000030	0.001207
19.00	0.000023	0.000989
19.50	0.000017	0.000814
20.00	0.000013	0.000673
20.50	0.000010	0.000557
21.00	0.000007	0.000463
21.50	0.000005	0.000386
22.00	0.000004	0.000323
22.50	0.000003	0.000270
23.00	0.000002	0.000226
23.50	0.000002	0.000190
24.00	0.000001	0.000160
24.50	0.000001	0.000134
25.00	0.000001	0.000113

Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.494	2.831	2.560	2.178	2.501
20%	4.148	4.508	4.241	3.573	4.129
10%	5.229	5.576	5.315	4.448	5.170
5%	6.272	6.569	6.330	5.263	6.151
1%	8.826	8.830	8.594	6.953	8.407

Vguat (m/s)

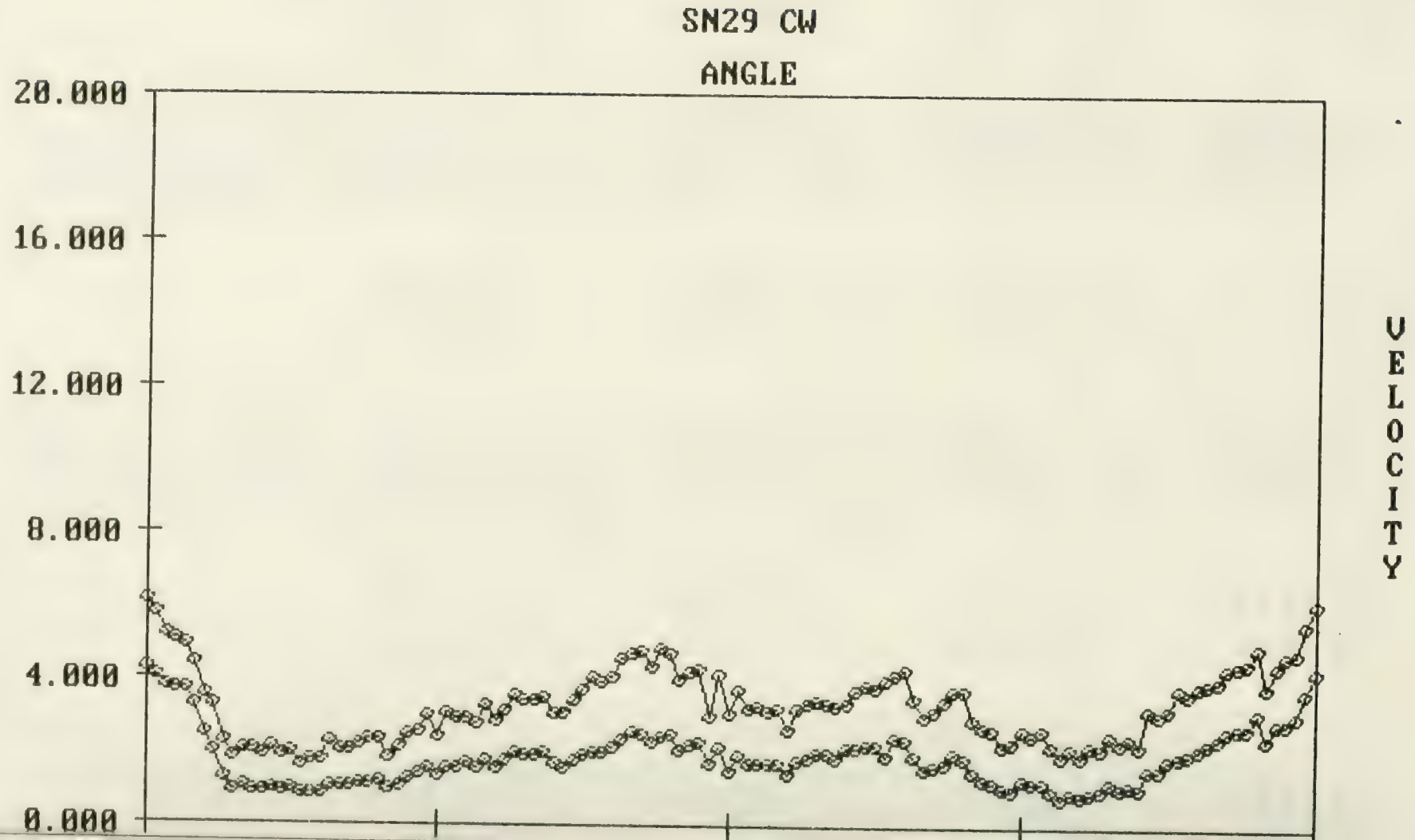
ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.196	4.770	4.296	3.662	4.211
20%	6.938	7.588	7.094	5.987	6.916
10%	8.699	9.323	8.856	7.420	8.615
5%	10.363	10.909	10.470	8.703	10.191
1%	14.316	14.349	13.938	11.329	13.677

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.578	6.333	5.728	4.872	5.593
20%	9.280	10.085	9.488	7.993	9.236
10%	11.697	12.473	11.890	9.949	11.565
5%	14.029	14.694	14.159	11.773	13.759
1%	19.742	19.753	19.224	15.554	18.807

Vguat (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	9.387	10.671	9.609	8.192	9.420
20%	15.519	16.974	15.869	13.392	15.472
10%	19.459	20.856	19.810	16.598	19.271
5%	23.182	24.402	23.420	19.469	22.797
1%	32.023	32.098	31.178	25.343	30.594


SN29 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
VELOCITY

BOSTON ANNUAL

elocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.887460	0.968252
1.00	0.646186	0.882323
1.50	0.422990	0.761914
2.00	0.265370	0.629470
2.50	0.162698	0.502009
3.00	0.097327	0.389140
3.50	0.056603	0.294689
4.00	0.032013	0.218827
4.50	0.017656	0.159730
5.00	0.009530	0.114759
5.50	0.005052	0.081186
6.00	0.002638	0.056553
6.50	0.001360	0.038787
7.00	0.000694	0.026199
7.50	0.000350	0.017440
8.00	0.000175	0.011456
8.50	0.000087	0.007438
9.00	0.000042	0.004785
9.50	0.000021	0.003058
10.00	0.000010	0.001949
10.50	0.000005	0.001243
11.00	0.000002	0.000796
11.50	0.000001	0.000515
12.00	0.000000	0.000336
12.50	0.000000	0.000223
13.00	0.000000	0.000150
13.50	0.000000	0.000102
14.00	0.000000	0.000070
14.50	0.000000	0.000049
15.00	0.000000	0.000034
15.50	0.000000	0.000024
16.00	0.000000	0.000017
16.50	0.000000	0.000012
17.00	0.000000	0.000009
17.50	0.000000	0.000006
18.00	0.000000	0.000004
18.50	0.000000	0.000003
19.00	0.000000	0.000002
19.50	0.000000	0.000001
20.00	0.000000	0.000001
20.50	0.000000	0.000001
21.00	0.000000	0.000000
21.50	0.000000	0.000000
22.00	0.000000	0.000000
22.50	0.000000	0.000000
23.00	0.000000	0.000000
23.50	0.000000	0.000000
24.00	0.000000	0.000000
24.50	0.000000	0.000000
25.00	0.000000	0.000000

Vmean (m/s)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.333	1.473	1.384	1.127	1.327
20%	2.362	2.517	2.391	1.945	2.318
10%	3.048	3.270	3.056	2.506	2.980
5%	3.719	3.924	3.693	3.062	3.634
1%	5.126	5.303	4.950	4.301	4.971

Vguat (m/s)

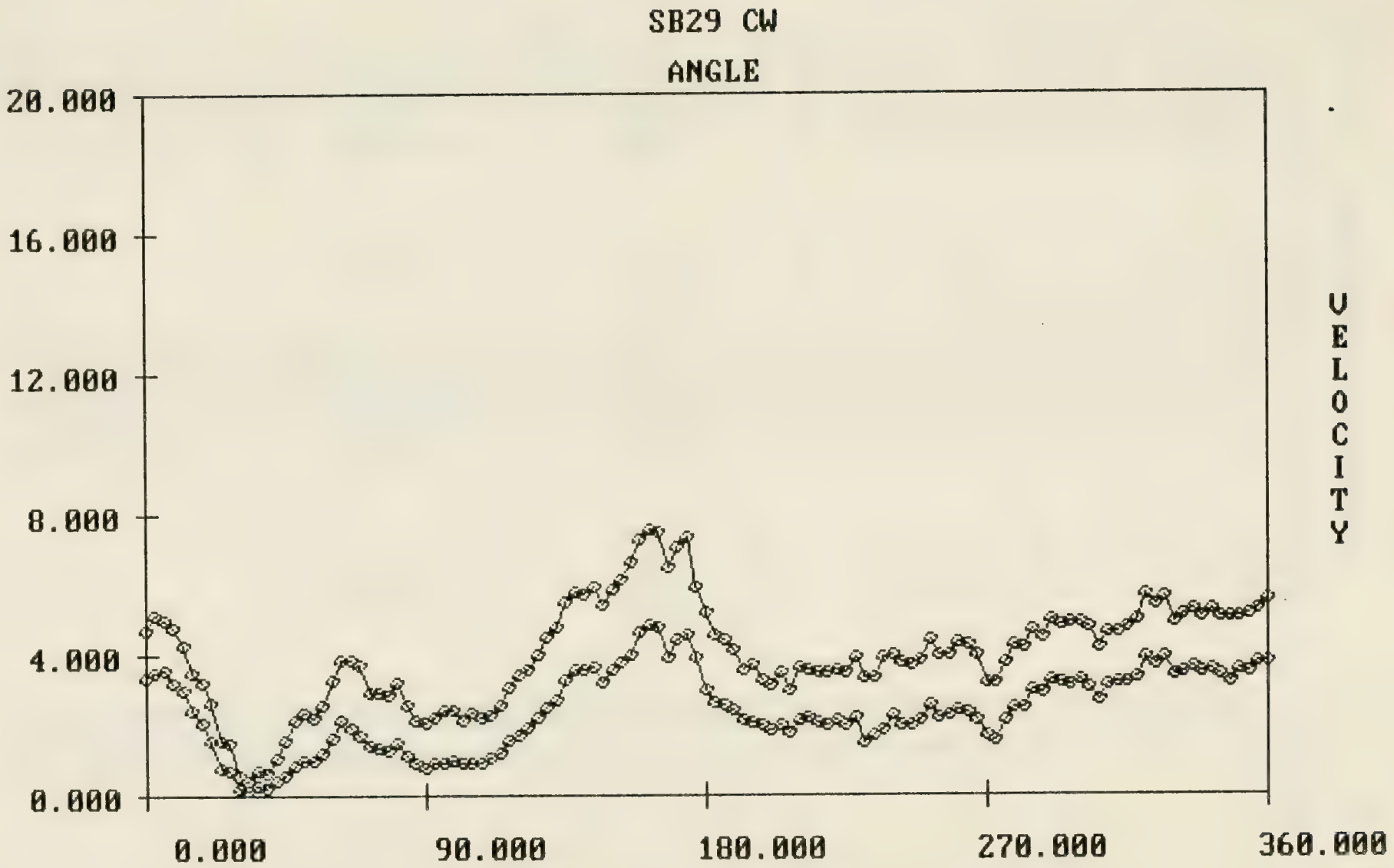
Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.503	2.855	2.611	2.131	2.509
20%	4.205	4.549	4.290	3.521	4.159
10%	5.308	5.648	5.337	4.437	5.220
5%	6.318	6.634	6.276	5.283	6.184
1%	8.472	8.612	8.151	6.991	8.181

Vmean (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	2.981	3.295	3.097	2.521	2.969
20%	5.283	5.630	5.349	4.352	5.186
10%	6.819	7.316	6.836	5.606	6.665
5%	8.318	8.778	8.260	6.850	8.130
1%	11.467	11.862	11.073	9.620	11.120

Vguat (mph)

Probability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	5.600	6.387	5.841	4.767	5.612
20%	9.407	10.177	9.598	7.876	9.304
10%	11.873	12.634	11.939	9.924	11.676
5%	14.132	14.839	14.039	11.818	13.834
1%	18.951	19.265	18.232	15.638	18.301


SB29 CW
ANGLE
20.000
16.000
12.000
8.000
4.000
0.000
0.000
90.000
180.000
270.000
360.000
VELOCITY

BOSTON ANNUAL

Velocity (m/s)	Probability Vmean	Probability Vgust
0.00	1.000000	1.000000
0.50	0.911911	0.966273
1.00	0.782404	0.905266
1.50	0.642196	0.829759
2.00	0.505219	0.744456
2.50	0.381840	0.655131
3.00	0.278411	0.566015
3.50	0.196477	0.480219
4.00	0.134434	0.400122
4.50	0.063119	0.241445
5.00	0.040098	0.192956
5.50	0.024686	0.151413
6.00	0.014734	0.116713
6.50	0.008536	0.088412
7.00	0.004810	0.065848
7.50	0.002646	0.048243
8.00	0.001429	0.034790
8.50	0.000762	0.024712
9.00	0.000405	0.017306
9.50	0.000216	0.011963
10.00	0.000117	0.008175
10.50	0.000065	0.005534
11.00	0.000037	0.003719
11.50	0.000021	0.002490
12.00	0.000013	0.001666
12.50	0.000008	0.001119
13.00	0.000005	0.000757
13.50	0.000003	0.000517
14.00	0.000002	0.000359
14.50	0.000001	0.000253
15.00	0.000001	0.000181
15.50	0.000000	0.000131
16.00	0.000000	0.000097
16.50	0.000000	0.000072
17.00	0.000000	0.000054
17.50	0.000000	0.000041
18.00	0.000000	0.000031
18.50	0.000000	0.000023
19.00	0.000000	0.000018
19.50	0.000000	0.000013
20.00	0.000000	0.000010
20.50	0.000000	0.000008
21.00	0.000000	0.000006
21.50	0.000000	0.000004
22.00	0.000000	0.000003
22.50	0.000000	0.000003
23.00	0.000000	0.000002
23.50	0.000000	0.000001
24.00	0.000000	0.000001
24.50	0.000000	0.000001
25.00	0.000000	0.000001

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Vmean (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	1.974	2.512	2.074	1.649	2.021
20%	3.373	4.072	3.630	2.809	3.478
10%	4.217	4.960	4.172	3.491	4.241
5%	4.949	5.740	4.336	4.144	4.785
1%	6.481	7.230	4.467	5.438	6.382

Vgust (m/s)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	3.334	4.101	3.448	2.806	3.385
20%	5.447	6.409	4.259	4.606	4.927
10%	6.687	7.701	4.379	5.657	6.295
5%	7.771	8.797	4.440	6.559	7.450
1%	10.021	10.923	4.488	8.382	9.759

Vmean (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	4.415	5.619	4.640	3.689	4.521
20%	7.546	9.108	8.120	6.283	7.781
10%	9.434	11.094	9.333	7.809	9.488
5%	11.071	12.839	9.700	9.271	10.704
1%	14.497	16.174	9.993	12.163	14.276

Vgust (mph)

ability	FALL	WINTER	SPRING	SUMMER	ANNUAL
50%	7.457	9.173	7.713	6.276	7.571
20%	12.184	14.336	9.526	10.304	11.022
10%	14.957	17.226	9.796	12.655	14.082
5%	17.384	19.678	9.931	14.671	16.665
1%	22.416	24.434	10.039	18.751	21.830

317\SB29

APPENDIX B

SEASONAL VARIATIONS AT THE WINDIEST POINTS

PEDESTRIAN WIND IMPACTS

In this section we consider the seasonal variations of the wind. We analyze in detail the seven locations that for the no-build condition, have gusts which exceed the BRA criteria, i.e., the wind is 31.5 mph more than one percent of the time. Table B-1 presents these locations in order of the 1% annual gust winds. Rather than repeat the phrase "gust winds exceeded 1% of the time" we will just say "the wind" in this section. For each location, we present the seasonal results for the no-build, and build condition. The summer winds are always less than the annual winds and are about 4.9 mph smaller. The windiest season is sometimes fall and sometimes winter, depending on the location. At only one condition was spring the windiest season. At six conditions fall was windiest, and at seven conditions winter was windiest. The maximum seasonal gust winds exceeded the annual gust winds by about 2.4 mph.

Note that the annual 1% gust speed is almost, but not exactly, the average of the seasonal 1% gust speed. A note on the computation is in order. For each season we compute a cumulation probability versus velocity. We then sum these probabilities at each velocity and divide by the number of seasons to get the annual cumulative probability versus velocity. The results of this calculation is presented for each point in Appendix A. This list is searched for the velocity corresponding to a cumulative probability of 1%. It is the velocity which is the annual 1% gust velocity.

A discussion for each of the seven windiest locations follows:

Point 27 - The south corner of the Fiduciary Trust Building. In both the build and no-build case the windiest season is fall. The addition of the new building reduces

the annual wind but has almost no effect on the fall gust winds. In both the build and no-build case the summer winds are less than the annual wind by 5 mph.

Point 26 - The north corner of Summer Street opposite Financial Center. For both the build and no-build cases fall is the windiest season. The fall winds exceed the annual by 2.6 mph for the no-build case and 2.4 mph for the build case. During the summer the winds are about 5.5 mph less than the annual wind.

Point 25 - The north corner of Financial Center. For both the build and no-build case there is very little variation in wind between the fall, winter and spring. For the no-build case spring is the windiest season and exceeds the annual wind by 1.4 mph. For the build case winter is windiest and exceeds the annual wind by 1.5 mph. The summer wind is smaller than the annual wind by 5.5 and 4.9 mph respectively for the no-build and build case.

Point 17 - The west corner of Financial Center. There is almost no difference between the build and no-build case. Winter is the windiest season and exceeds the annual wind by 2.8 mph. The summer winds are smaller than the annual winds by 4 mph.

Point 12 - The south corner of 100 Summer Street. There is almost no difference between the build and no-build case. Fall is the windiest season with winds that exceed the annual winds by 1.8 mph. The summer winds are smaller than the annual winds by 4 mph.

Point 11 - The southeast corner of 100 Summer Street. Winter is the windiest season. Both the build and no-build cases have winds that exceed the annual wind by 2.4 mph. The summer winds are smaller by 4.5 mph.

Point 10 - The apex of the intersection of Summer and West Bedford Streets. Winter is the windiest season and has winds that exceed the annual wind by 2.4 mph. The summer winds are smaller than the annual winds by 5.6 mph.

TABLE B-1

125 SUMMER STREET

GUST VELOCITIES (MPH) EXCEEDED 1% OF THE TIME

SEVEN WINDIEST LOCATIONS

SEASONAL EFFECTS

Location	Fall	Winter	Spring	Summer	Annual
27 N	40.0	39.9	38.1	33.0	38.1
B	39.9	37.2	35.8	30.3	35.4
26 N	40.4	39.2	37.9	32.4	37.8
B	39.6	38.6	37.5	31.7	37.2
25 N	38.2	38.6	38.7	31.8	37.3
B	37.8	38.4	38.1	32.0	36.9
17 N	35.2	37.1	34.1	30.2	34.3
B	34.7	37.1	34.0	30.3	34.2
12 N	35.2	34.8	33.4	29.5	33.4
B	35.4	34.7	33.9	29.3	33.5
11 N	32.1	35.0	33.3	27.9	32.6
B	33.8	36.4	34.5	29.5	34.0
10 N	31.3	34.8	33.6	26.8	32.4
	30.3	33.6	32.3	25.5	31.2

N = No-Build

B = Build

APPENDIX B

TRAFFIC MAINTENANCE AGREEMENT

1489/1286/wpr

Turner Construction Company
150 Federal Street
Boston, MA 02110
(617) 542-8418

rner

125 SUMMER STREET
BOSTON, MASSACHUSETTS
CONTRACT NO. 4434

July 9, 1986

Traffic and Parking Department
City of Boston
One City Hall Plaza, Room 721
Boston, MA 02201

ATTENTION COMMISSIONER DIMINO RE: TRAFFIC MAINTENANCE AGREEMENT
125 Summer Street

Gentlemen:

Turner Construction Company has long recognized the need for proper planning of all operations as they relate to the construction of any project, large or small. Pursuant with the above position, we propose the following plan as a mechanism to successfully administer the construction activities associated with the 125 Summer Street project.

Turner's Project Superintendent will be the point person for all communication between the Traffic and Parking Department and the jobsite. He will have reporting to him an administrative assistant who will act as the information control center for project operations.

In our procurement process, we will specifically require every subcontractor on the project to comply with Traffic Maintenance Agreement, both contractually and through a formal operational review process in which we will evaluate their particular operational requirements. In addition, each subcontractor who requires occupational permits will coordinate those requirements with the Project Superintendent prior to application for said permit. The Project Superintendent shall issue a letter, addressed to Traffic and Parking, to indicate that he has reviewed the subcontractor's request for occupation and found it in concurrence with the Traffic Maintenance Agreement.

The 125 Summer Street project is bounded by Lincoln Street, Summer Street, South Street and the Surface Artery. The plan is as follows:

A. LINCOLN STREET

The plan calls for minimal use of this street. The two temporary elevators necessary for construction of the project will be located within the permanent receiving area that is accessed off Lincoln Street. These elevators will be accessed by a temporary loading dock constructed to the curb line.

A. LINCOLN STREET (Continued)

Miscellaneous daily deliveries will be made to this dock throughout the project. Ultimately this dock will be removed, and the building will be serviced through the permanent receiving area. This construction service requirement will be needed from October 1987 through June 1989.

B. SUMMER STREET

The plan calls for no construction-related deliveries to be made on Summer Street during normal working hours. We will be providing a lighted pedestrian walkway along the Summer Street elevation. This walkway will be approximately 7'-0" wide and 7'-0" high at Lincoln Street and 5'-0" wide and 7'-0" high at South Street. The location of this walkway will be in Summer Street proper immediately adjacent to the exterior facade support system associated with the project. At the South Street end, this walkway will pass under the exterior facade support system so as to minimize congestion as traffic turns from Summer Street onto South Street. This walkway will be in place from February 1987 through May 1989.

C. SOUTH STREET

The only deliveries called for in the plan to be made on South Street are the stone and steel backup assemblies. These assemblies will be stored on flat bed trailers. These trailers will be unloaded from the South Street elevation by an overhead crane. These trailers will be stored one at a time within the construction fence. This marshalling area will be in service from March 1988 through March 1989.

D. THE SURFACE ARTERY

The Surface Artery and the adjacent state-owned land become the major receiving/unloading area in the plan. Demolition debris, excavation, concrete and structural steel will all be marshalled in this area. This plan, however, dictates two (2) necessary events: 1) the current MBTA bus stop is relocated, and 2) an access lane be provided on the Surface Artery. This access lane shall be designated as a day lane, i.e., available for use only from the hours of 6 a.m. through 3:30 p.m. weekdays. During these hours this lane will be defined by a flexible, removable barricade system. The day lane will be in use from November 1987 through December 1988. The area on the state-owned land will be in use from November 1986 through June 1989.

E. MAJOR DELIVERY TRUCK ROUTING

The plan calls for major deliveries and earth removal equipment traveling northbound on the Expressway to exit at Lincoln Street, right turn onto Kneeland, left turn onto Atlantic, left turn onto Summer, left turn onto Surface Artery and into the major receiving/unloading area outlined above.

E. MAJOR DELIVERY TRUCK ROUTING (Continued)

Major deliveries and earth removal equipment traveling southbound on the Expressway are required to exit at South Station, onto the Surface Artery and into the major receiving/unloading area.

We respectfully submit this plan for your approval and use. Any changes to this plan necessitated by either unanticipated changes in the construction process at 125 Summer Street or any other extraneous activities not associated with the project will be implemented only upon concurrence with the Traffic and Parking Department together with Turner's Project Superintendent.

Very truly yours,

TURNER CONSTRUCTION COMPANY

Charles T. Buuck
Project Executive

CTB:mcj

APPROVED: CITY OF BOSTON TRAFFIC AND PARKING DEPARTMENT

By _____

Date _____

STUDY INTERSECTION
TURNING MOVEMENT COUNTS

1. Congress Street/Purchase Street
2. Kneeland Street/Atlantic Avenue/Turnpike Ramp
3. Summer Street/Lincoln Street/Bedford Street
4. Surface Road/South Street/Expressway Ramp

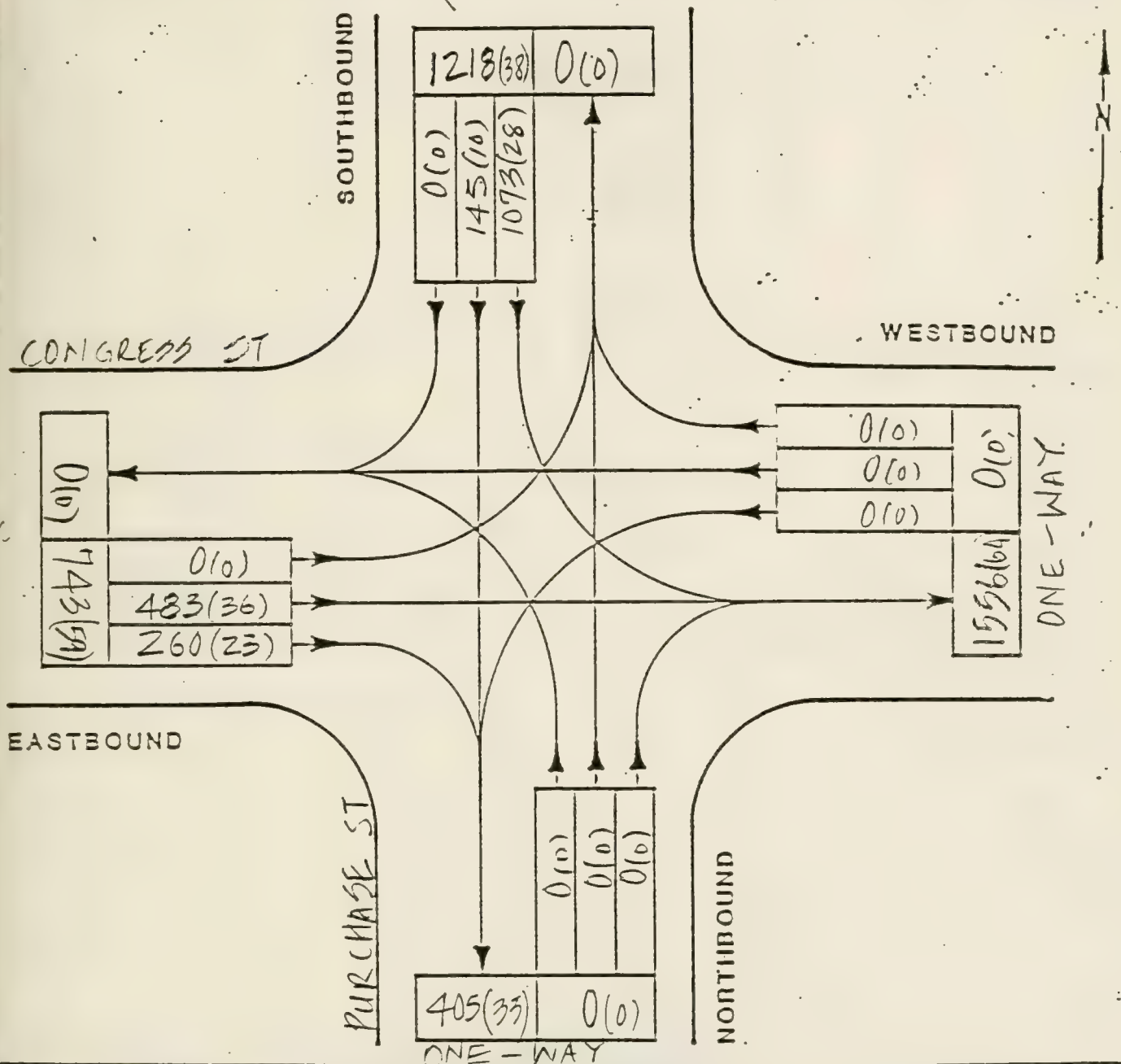
1489/1286/wpr

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION TURNING MOVEMENT COUNT

CITY BOSTON, MA DATE 4/30/86 DAY of WEEK WEDNESDAY

INTERSECTION CONGRESS / PURCHASE ST JOB No. 1489

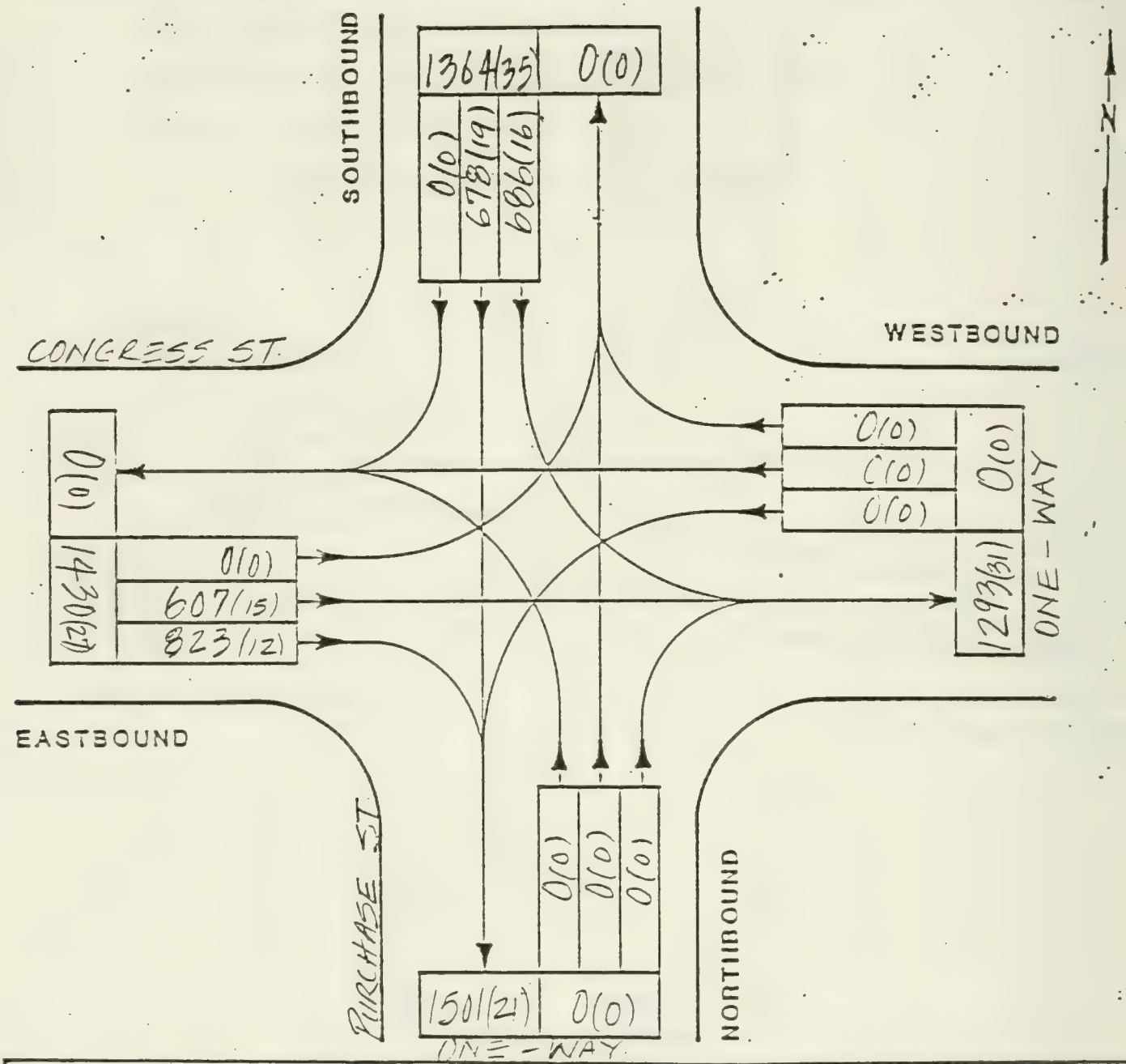


STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
PURCHASE ST (S. B)	1218 (38)	62.1	7:45 - 8:45
CONGRESS ST (E. B)	743 (59)	37.9	
			AM. PEAK HOUR
			VEHICLES COUNTED
			ALL VEHICLES XXX 1961
			TRUCKS (XX) 97
TOTAL	1961 (97)	100%	PERCENT TRUCKS 4.9 %

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION TURNING MOVEMENT COUNT

CITY BOSTON, MA DATE 4/30/86 DAY of WEEK WEDNESDA
INTERSECTION CONGRESS / PURCHASE ST JOB No. 1459



STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
PURCHASE ST (S.B)	1364(35)	48.8	4:45 - 5:45
CONGRESS ST (E.B)	1430(27)	51.2	
			P.M.
			VEHICLES COUNTED
			ALL VEHICLES XXX
			TRUCKS (XX)
TOTAL	2794(62)	100%	PERCENT TRUCKS %

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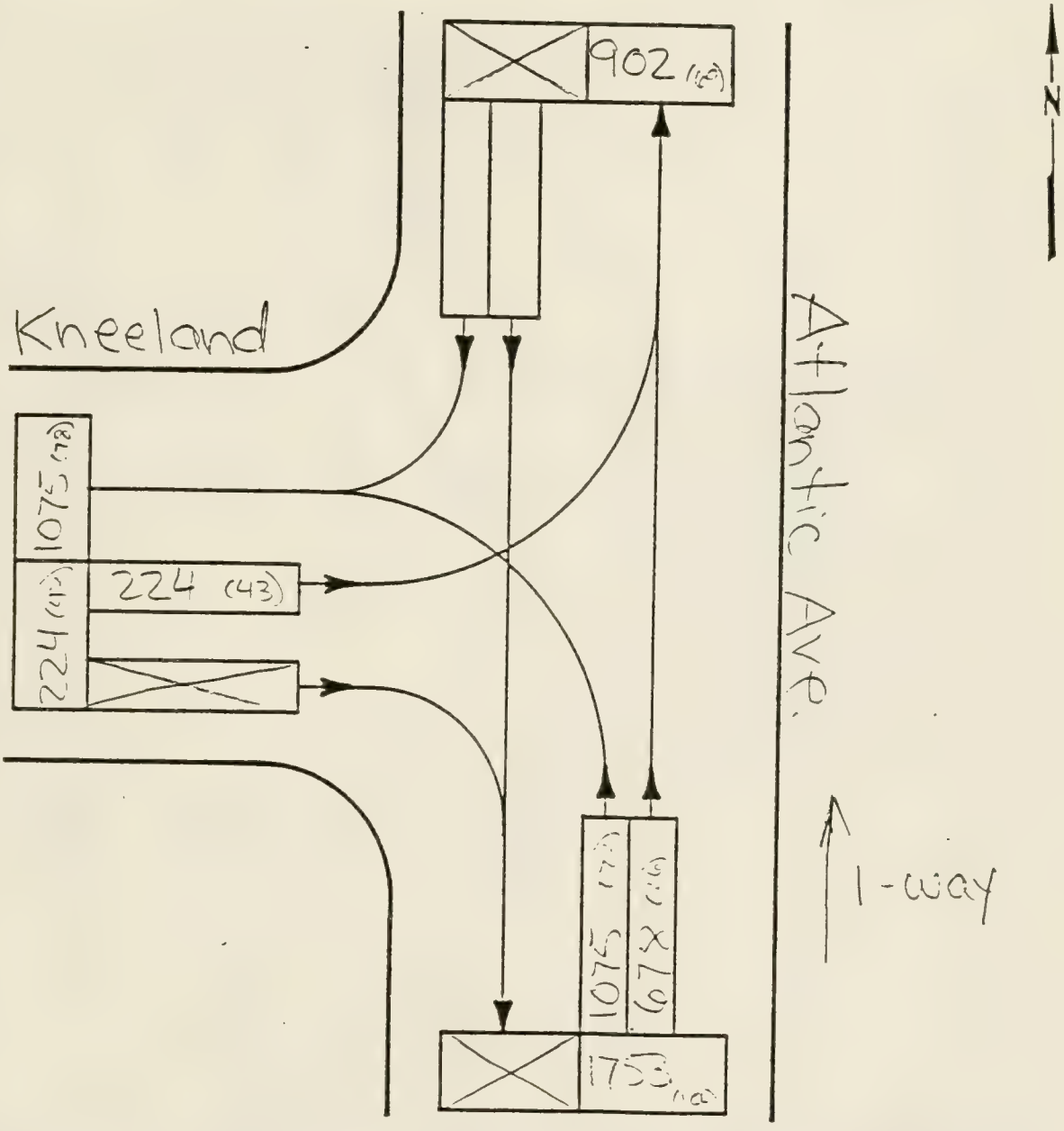
INTERSECTION TURNING MOVEMENT COUNT

CITY Boston DATE 4/30 DAY of WEEK W

INTERSECTION Atlantic Ave. / Kneeland St. JOB No. 1429



STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
Kneeland EB	224 (43)	11.3 %	AM Peak
Atlantic Ave. NB	75- (5)	22.7	
			8-9
			VEHICLES COUNTED
			ALL VEHICLES XXX 477
			TRUCKS (XX) 27
TOTAL	1977	100 %	PERCENT TRUCKS 7.4 %

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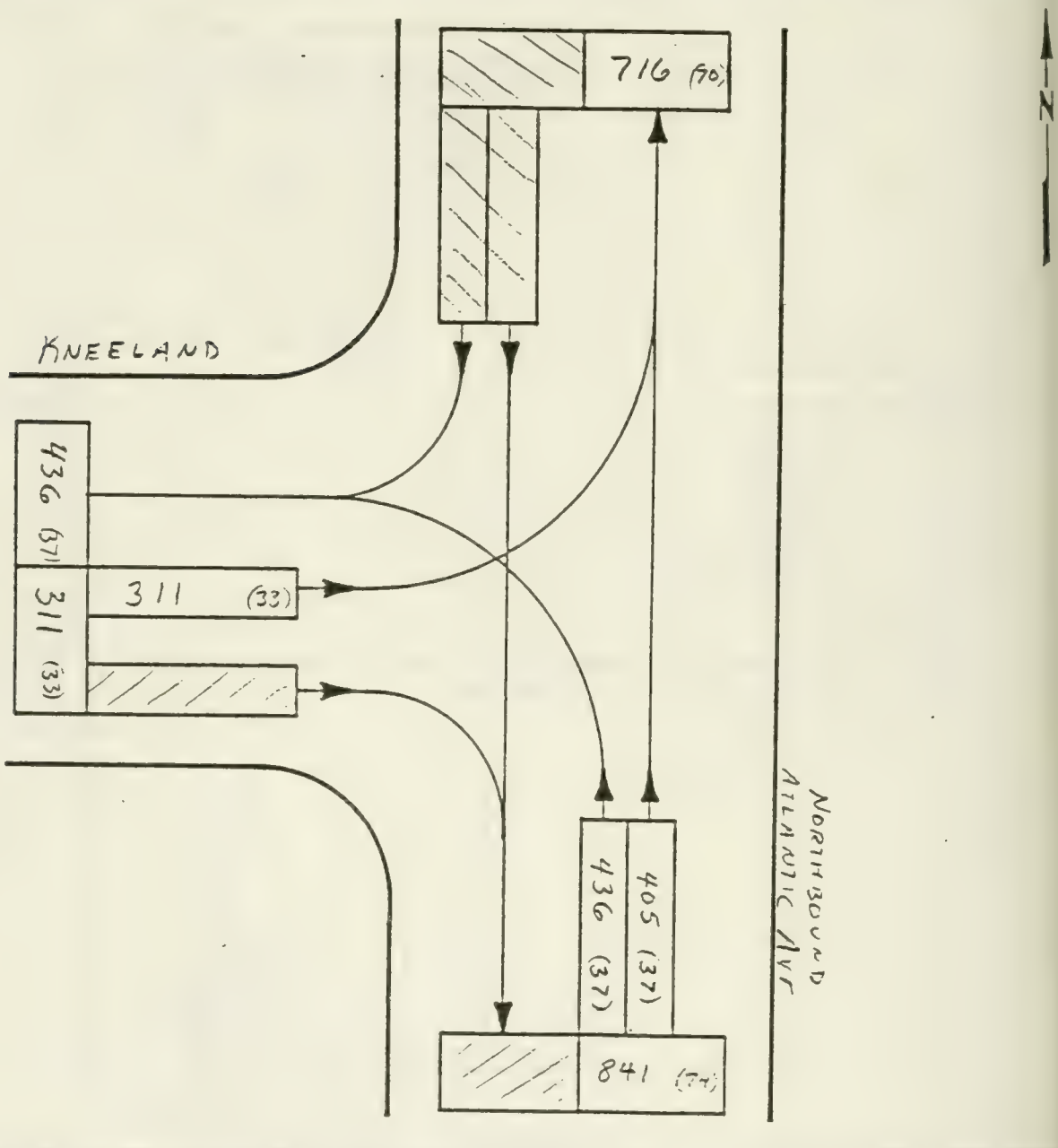
617/783-7000

INTERSECTION TURNING MOVEMENT COUNT

CITY Boston, MA DATE 4/30/86 DAY of WEEK THURSDA

INTERSECTION Kneeland St / Atlantic Ave JOB No. 1489



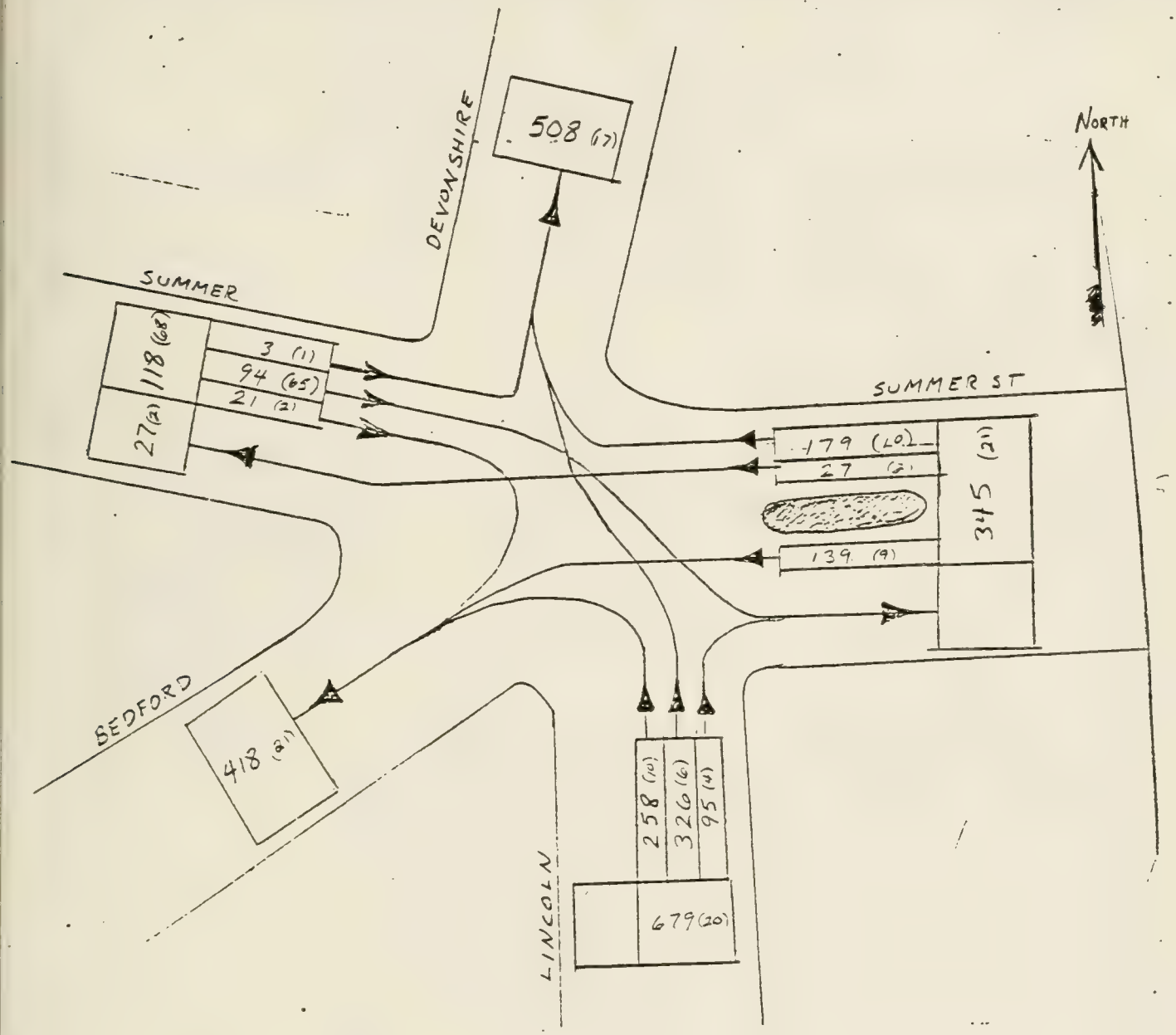
STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
ATLANTIC AVE (NB)	841 (74)	73 %	PM PEAK
KNEELAND ST (EB)	311 (33)	27 %	
			4 - 5 PM
			VEHICLES COUNTED
			ALL VEHICLES XXX 1152
			TRUCKS (XX) 107
TOTAL	1152 (107)	100 %	PERCENT TRUCKS 9.3 %

617/783-7000

ERSECTION TURNING-MOVEMENT COUNT

BOSTON, MA DATE 5/1/86 DAY of WEEK THURSDAY

RSECTION LINCOLN / BEDFORD / SUMMER JOB No. 1489



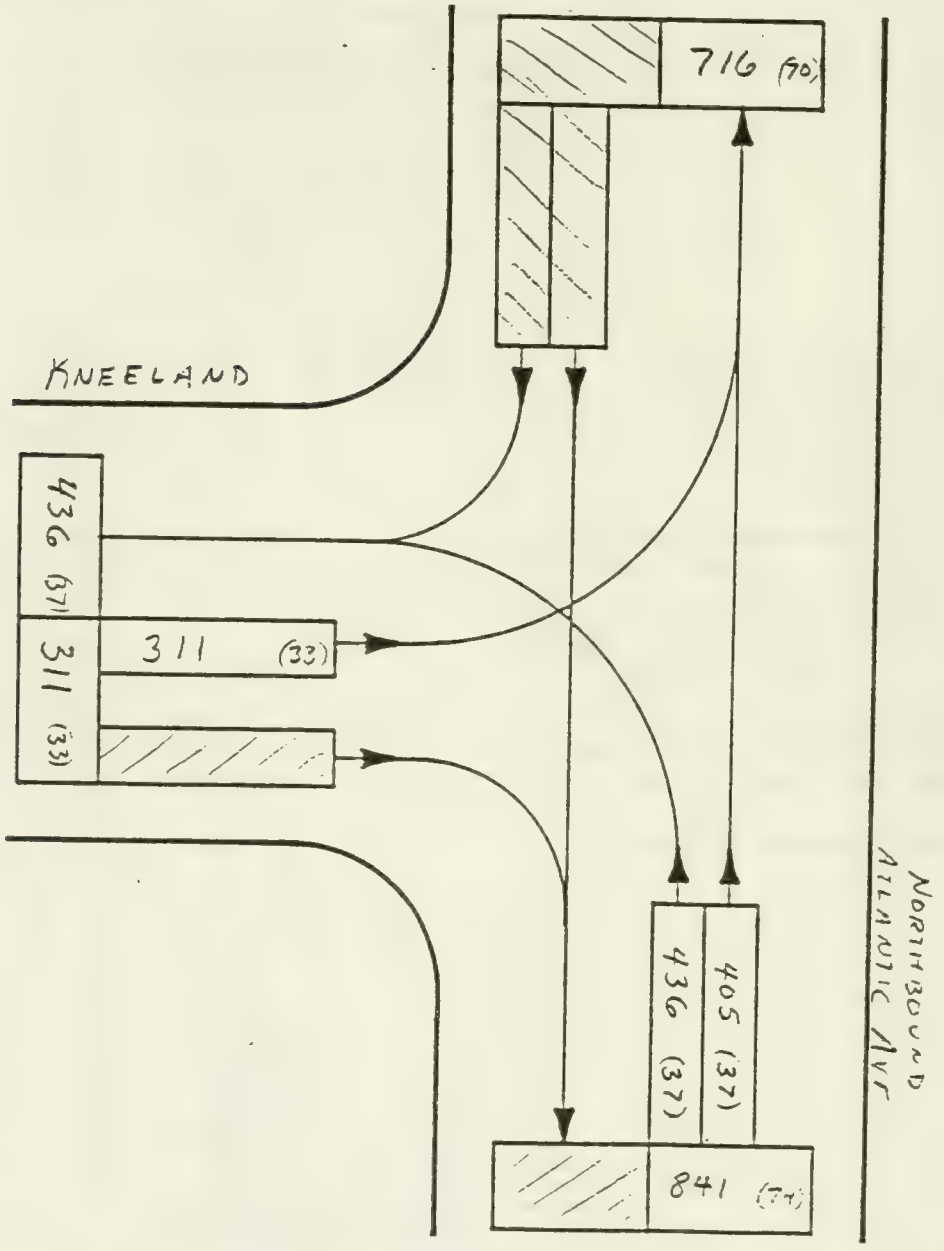
STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
NCOLN ST (NORTHBOUND)	679 (20)	60 %	7:45 - 8:45
MMER ST (EASTBOUND)	118 (68)	10 %	
MMER ST (WESTBOUND)	345 (21)	30 %	AM PEAK
			VEHICLES COUNTED
			ALL VEHICLES XXX 1142
			TRUCKS (XX) 109
TOTAL	1142 (109)	100 %	PERCENT TRUCKS 9.5 %

60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION TURNING MOVEMENT COUNT

CITY Boston, MA DATE 4/30/86 DAY of WEEK THURSDA

INTERSECTION Kneeland St / Atlantic Ave JOB No. 1489



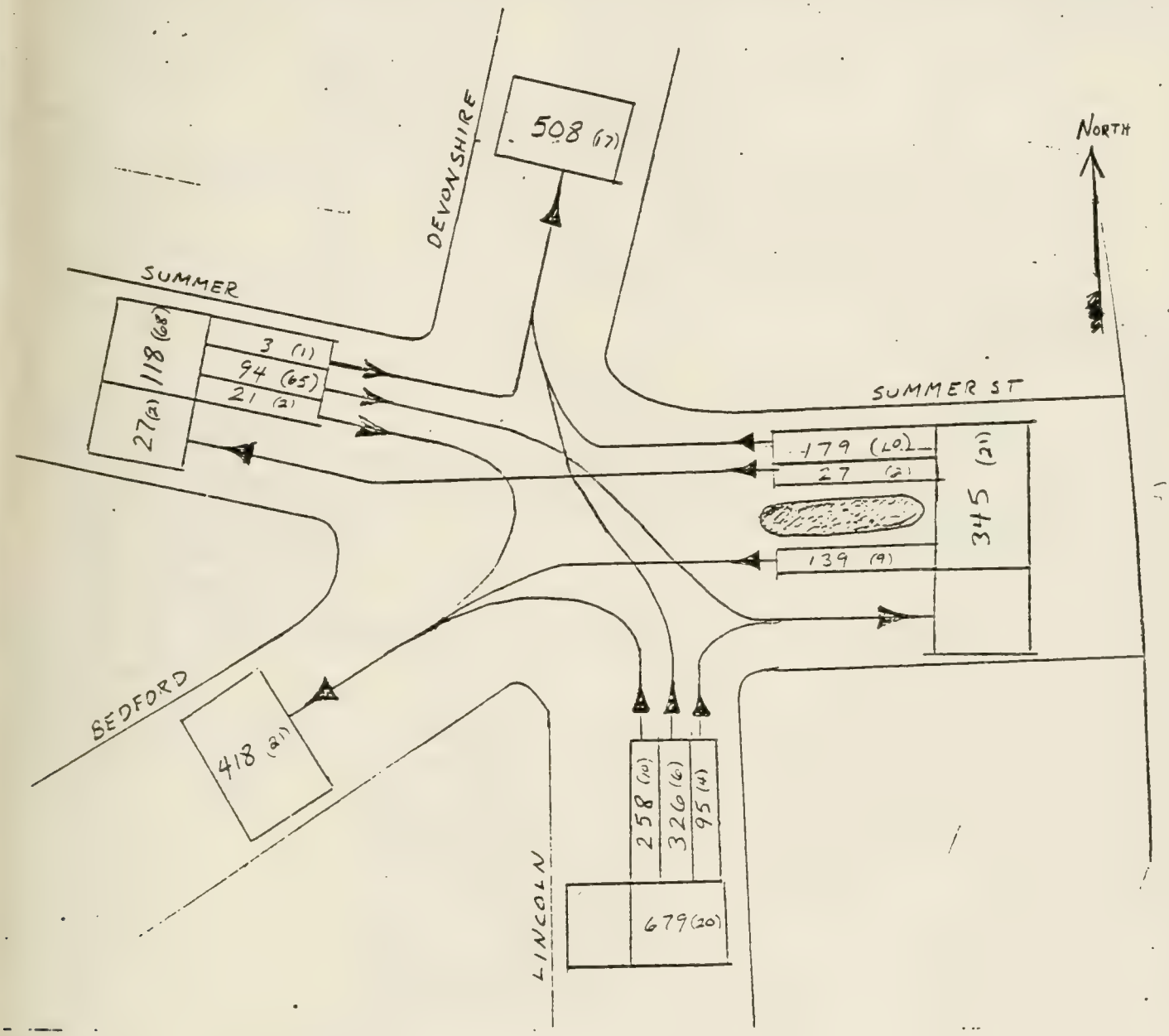
STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
ATLANTIC AVE (NB)	841 (74)	73 %	PM PEAK
KNEELAND ST (EB)	311 (33)	27 %	
			4 - 5 PM
			VEHICLES COUNTED
			ALL VEHICLES XXX 1152
			TRUCKS (XX) 107
TOTAL	1152 (107)	100 %	PERCENT TRUCKS 9.3 %

617/783-7000

TERSECTION TURNING-MOVEMENT COUNT

Y BOSTON, MA DATE 5/1/86 DAY of WEEK THURSDAY

ERSECTION LINCOLN / BEDFORD / SUMMER JOB No. 1489



STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
LINCOLN ST (NORTHBOUND)	679 (20)	60 %	7:45 - 8:45
SUMMER ST (EASTBOUND)	118 (68)	10. %	
SUMMER ST (WESTBOUND)	345 (21)	30 %	AM PEAK
			VEHICLES COUNTED
			ALL VEHICLES XXX 1142
			TRUCKS (XX) 109
TOTAL	1142 (109)	100 %	PERCENT TRUCKS 9.5 %

60 Birmingham Parkway, Boston, MA 02135
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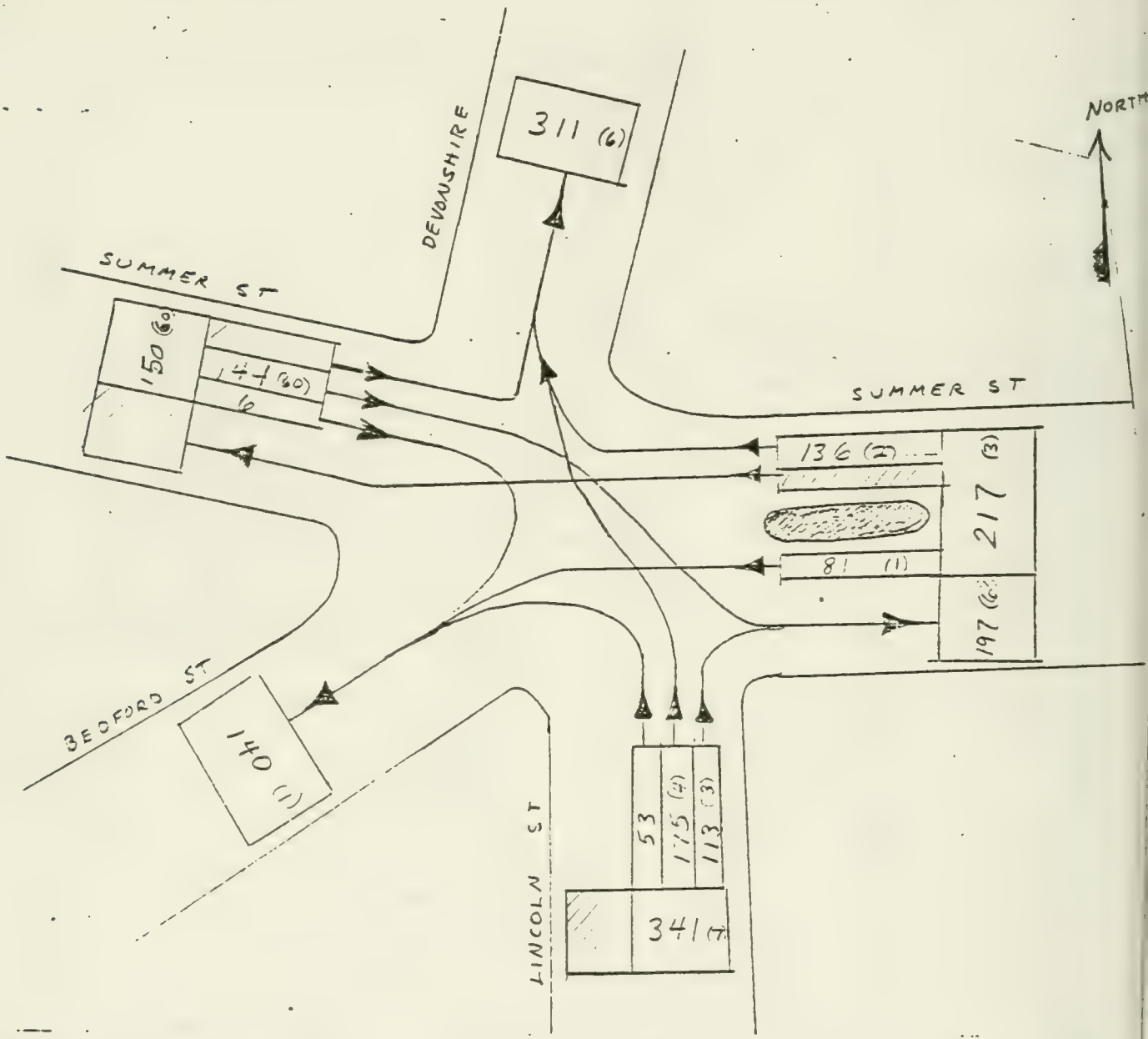
INTERSECTION TURNING MOVEMENT COUNT

CITY Boston, MA DATE 4/30/86 DAY of WEEK WEDNESDA

INTERSECTION BEDFORD ST/LINCOLN ST/ SUMMER ST JOB No. 1489



STREET	ENTERING VOLUME	PERCENT OF FLOW	TIME of COUNT
LINCOLN ST (NORTHBOUND)	341 (7)	48.8%	4:45 - 5:45 PM
SUMMER ST (EASTBOUND)	150 (60)	21.2%	
SUMMER ST (WESTBOUND)	217 (3)	30 %	PM PEAK HOUR
			VEHICLES COUNTED
			ALL VEHICLES XXX 708
			TRUCKS (XX) 70
TOTAL	708 (70)	100 %	PERCENT TRUCKS 10 %

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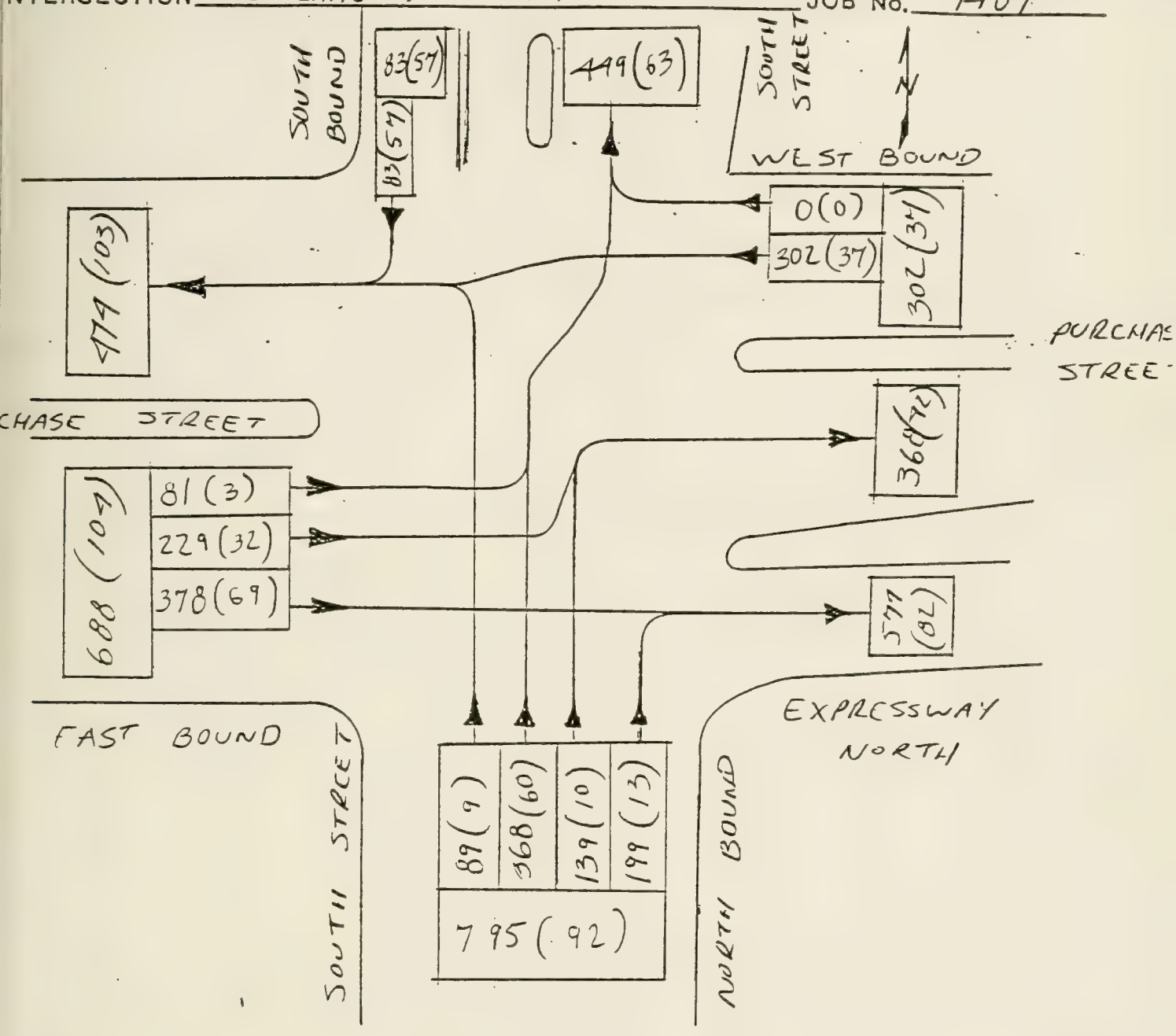
INTERSECTION TURNING MOVEMENT COUNT

CITY BOSTON, MA DATE 5-7-86 DAY of WEEK WEDNESDA

INTERSECTION PURCHASE & SOUTH JOB No. 1489



STREET		ENTERING VOLUME		PERCENT OF FLOW	TIME of COUNT
SOUTH ST.	NB	795	(92)	42.6 %	7:30 - 8:30
SOUTH ST.	SB	83	(57)	4.4 %	
PURCHASE ST	EB	688	(104)	36.8 %	A.M. PEAK HOUR
PURCHASE ST.	WB	302	(37)	16.2 %	
					VEHICLES COUNTED
					ALL VEHICLES XXX 1868
					TRUCKS (XX) 290
TOTAL		1868	(290)	100 %	PERCENT TRUCKS 15.5%

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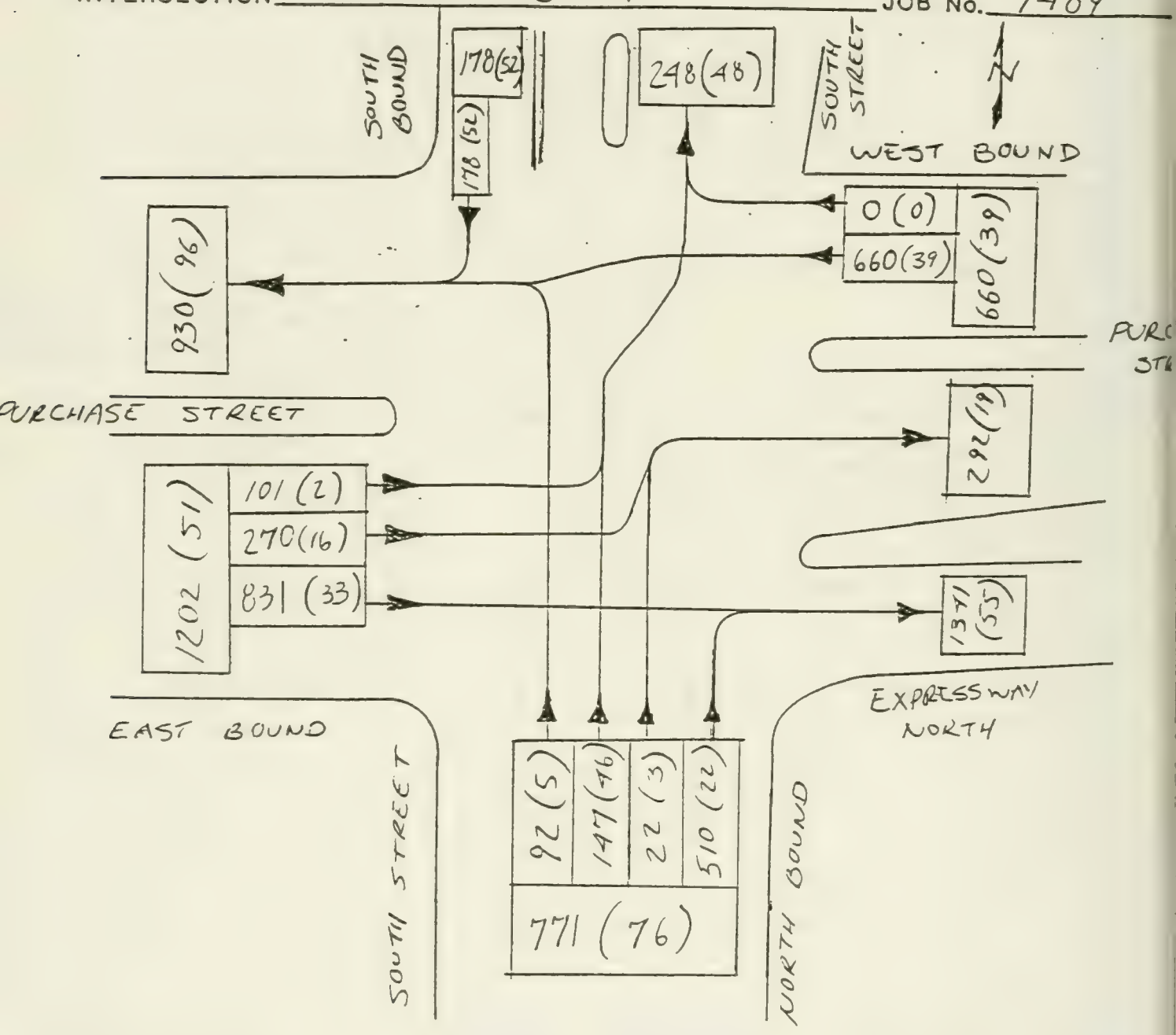
INTERSECTION TURNING MOVEMENT COUNT

CITY BOSTON, MA DATE 5-7-86 DAY of WEEK WEDN

INTERSECTION PURCHASE / SOUTH JOB No. 1489



STREET		ENTERING VOLUME		PERCENT OF FLOW	TIME of COUNT
SOUTH ST.	NB	771	(76)	27.4 %	4:00 - 5:00
SOUTH ST.	SB	178	(52)	6.3 %	
PURCHASE ST	EB	1202	(51)	42.8 %	P.M. PEAK HOUR
PURCHASE ST.	WB	660	(39)	23.5 %	
					VEHICLES COUNTED
					ALL VEHICLES XXX 2811
					TRUCKS (XX) 219
TOTAL		2811	(218)	100 %	PERCENT TRUCKS 7.8 %

STUDY INTERSECTION
LEVEL OF SERVICE ANALYSIS

1. Congress Street/High Street
2. Congress Street/Purchase Street
3. Congress Street/Atlantic Avenue
4. Federal Street/High Street
5. Kneeland Street/SurfaceRoad/Southeast Expressway Ramp
6. Kneeland Street/Lincoln Street/Southeast Expressway Ramp
7. Kneeland Street/Atlantic Avenue/Turnpike Ramp
8. Summer Street/Lincoln Street/Bedford Street
9. Summer Street/South Street/High Street
10. Summer Street/Surface Road/Purchase Street
11. Summer Street/Atlantic Avenue
12. Surface Road/Essex Street/Lincoln Street
13. Surface Road/South Street/Expressway Ramp

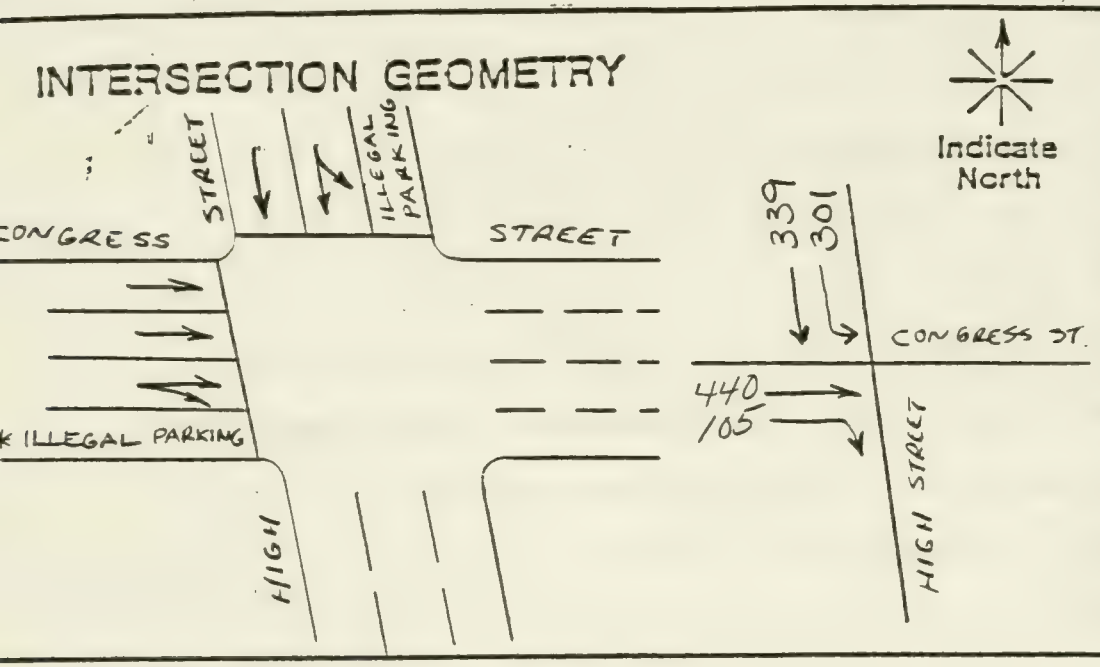
1489/1286/wpr

(#14)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION CONGRESS & HIGH STREET
ALT. Existing YEAR 1986 PERIOD P.M.
CALCULATED BY RAR DATE 5/23/86 SHEET 1
CHECKED BY HWM DATE 5/27/86 JOB NO. 14
Rev 10/14/86

INTERSECTION GEOMETRY



Left Turn Che

	Accm 1	Accm 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
⊥⊥ 182 → 187 → 76 ↘ 105	⊥⊥⊥ 320 ↓ 301 ↘			
CLV= 182	CLV= 320	CLV=	CLV=	CLV=

NOTE: 30% reduction in 2Ø criteria due to pedestrians

Σ CLV 502
V/C .48
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

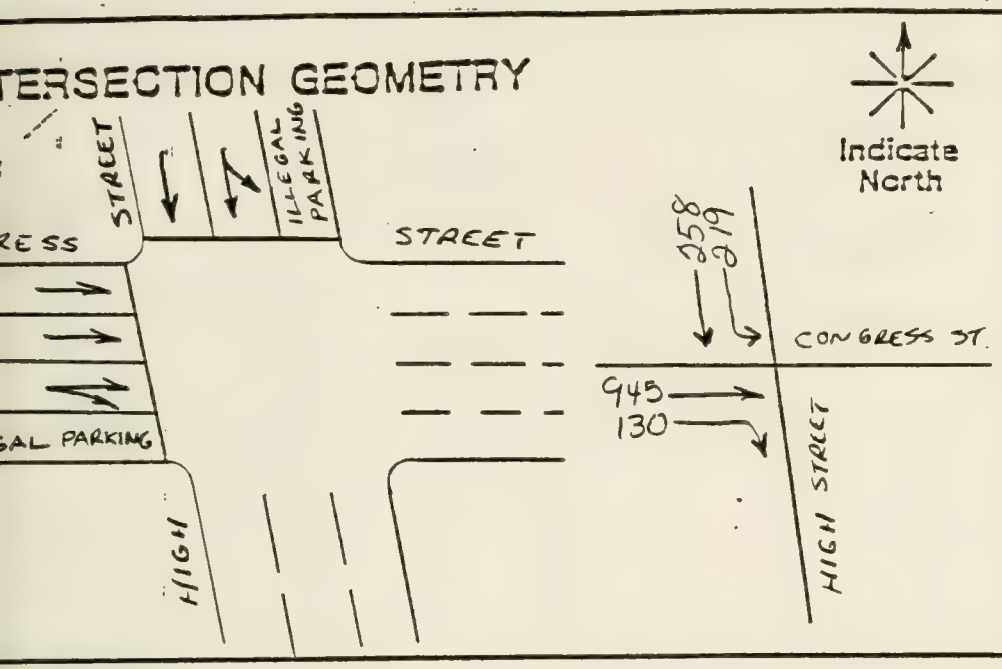
450

(#14)

sse/Hangen Engineering, Inc.
ting Engineers & Planners
ningham Parkway, Boston, MA 02135
3-7000

INTERSECTION CONGRESS & HIGH STREET
ALT. Existing YEAR 1986 PERIOD PM.
CALCULATED BY IRAR DATE 2-23-86 SHEET 2 OF 6
CHECKED BY HWM DATE 5/27/86 JOB NO. 1-189
Rev. 10/14/86

TERSECTION GEOMETRY



Indicate North

Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

(A)	(B)	(C)	(D)	(E)
359 358 228 130	238 239 19 219			
CLV= 359	CLV= 239	CLV=	CLV=	CLV=

NOTE: 30% reduction in 2Ø criteria due to pedestrians

Σ CLV 598
V/C .57
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

CSC

(#14)

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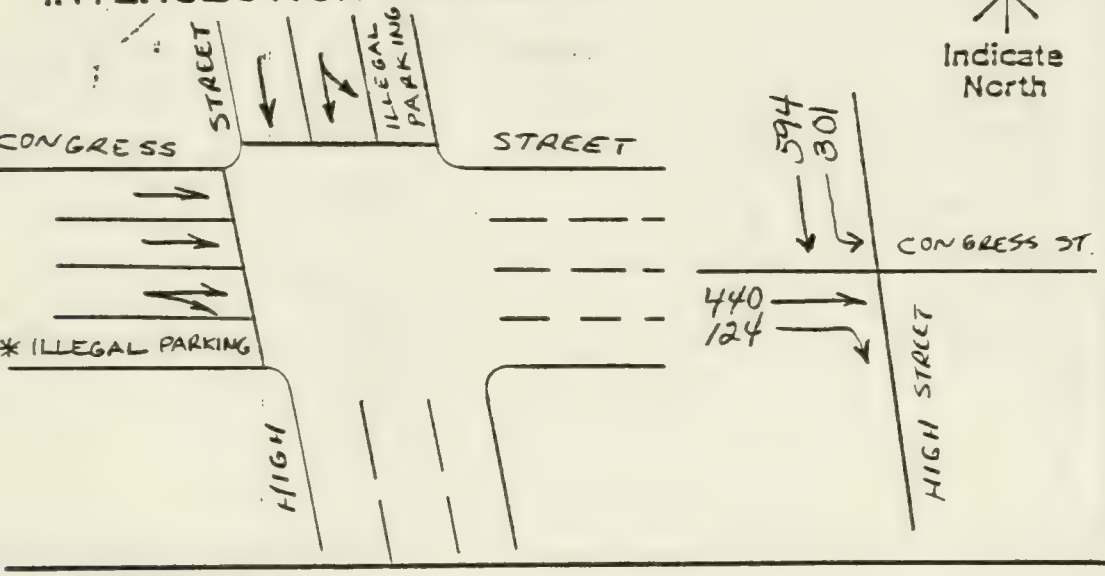
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION CONGRESS & HIGH STREET
ALT. No. Build YEAR 1989 PERIOD A.M
CALCULATED BY RAR DATE 5-23-86 SHEET 3 O
CHECKED BY HWM DATE 5-27-86 JOB NO. 1 18
Rev 6/14/86

INTERSECTION GEOMETRY



Left Turn Chec

	Accord 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
188 → 188 188 ↰ 15 ↓ 173	447 → 301 448 ← 146			
CLV= 188	CLV= 448	CLV=	CLV=	CLV=

NOTE: 30% reduction in 2Ø criteria due to pedestrians

Σ CLV 636
V/C .60
LOS A

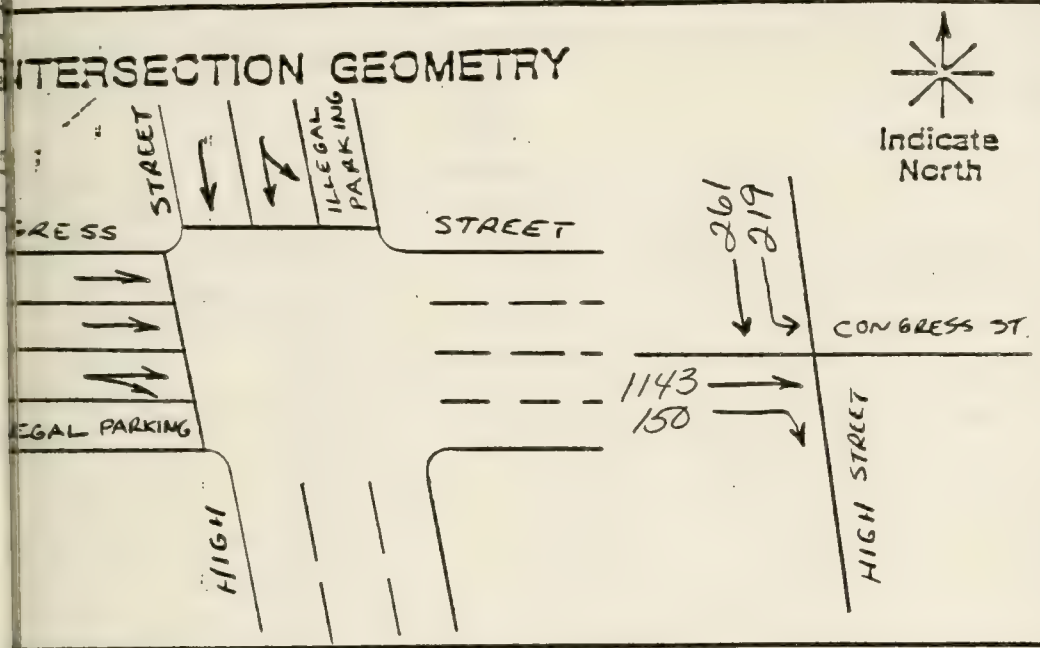
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

450

asse/Hangen Engineering, Inc.
sulting Engineers & Planners
irmingham Parkway, Boston, MA 02135
783-7000

INTERSECTION CONGRESS & HIGH STREET
ALT. No Build YEAR 1989 PERIOD P.M.
CALCULATED BY RAR DATE 7-22-86 SHEET 4 OF 6
CHECKED BY HJM DATE 7-27-86 JOB NO. 1489
Rev. 10/14/86

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
431 431 281 150	240 21 219			
CLV= 431	CLV= 240	CLV=	CLV=	CLV=

NOTE: 30% reduction in 2Ø criteria due to pedestrians

Σ CLV 671
V/C .64
LOS B

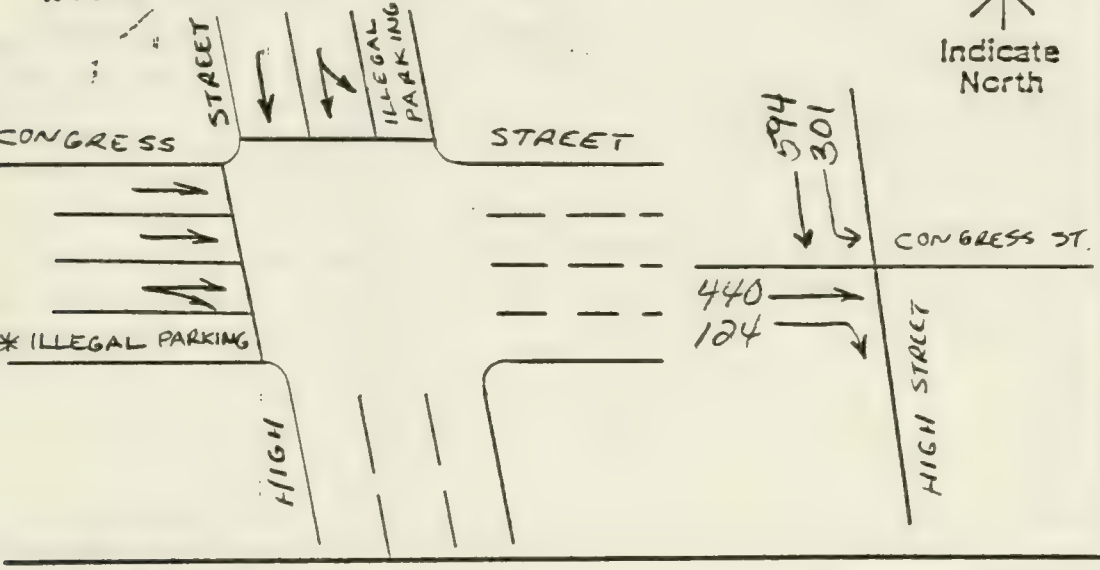
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

VHE (#14)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION CONGRESS & HIGH STREET
ALT. Build YEAR 1989 PERIOD A.M.
CALCULATED BY RAR DATE 5/22/89 SHEET 5 OF
CHECKED BY RWM DATE 5/27/89 JOB NO. 11478
Rev. 10/14/89

INTERSECTION GEOMETRY



Left Turn Chec

	Approa 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
188 → 188 → 15 ↘ 173 (184)	447 → 301 ↘ 146 (472)			
CLV= 188	CLV= 448	CLV=	CLV=	CLV=

NOTE: 30% reduction in 2Ø criteria due to pedestrians

Σ CLV 1636
V/C .60
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

.850

(#14)

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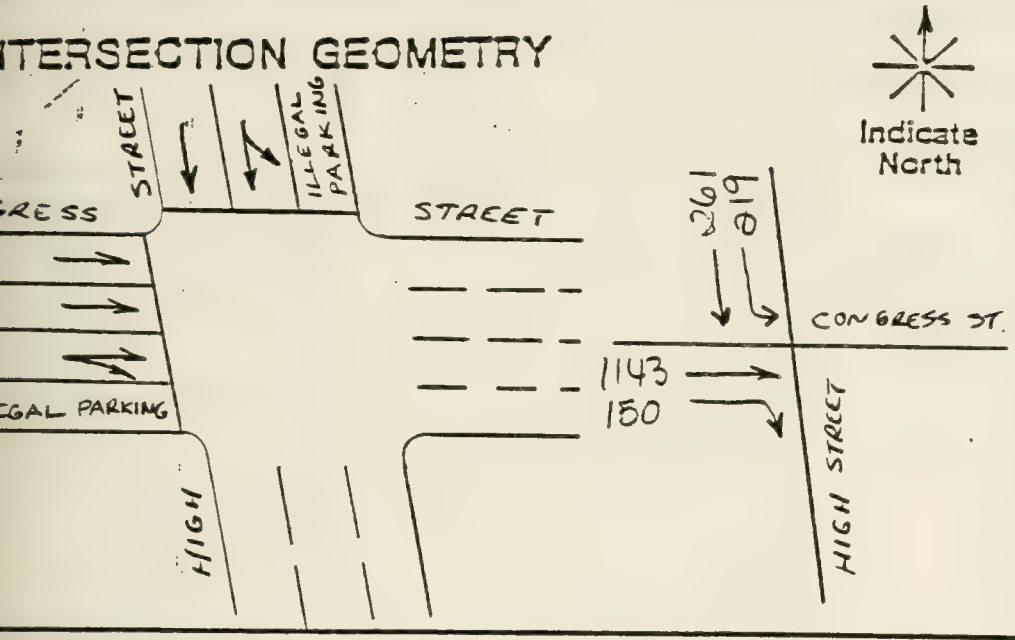
INTERSECTION CONGRESS & HIGH STREET
ALT. Build YEAR 19 PERIOD P.M.
CALCULATED BY RAR DATE 5/23/86 SHEET 5 OF 6
CHECKED BY HWM DATE 5/27/86 JOB NO. 1489

INTERSECTION GEOMETRY



Indicate North

Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

(A)	(B)	(C)	(D)	(E)
431 431 281 150	240 21 219			
CLV= 431	CLV= 240	CLV=	CLV=	CLV=

NOTE: 30% reduction in 2Ø criteria due to pedestrians

Σ CLV 671
V/C .64
LOS B

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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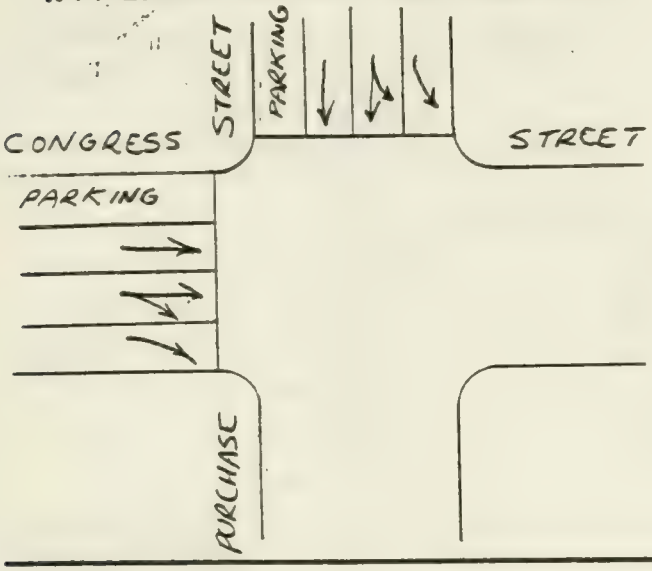
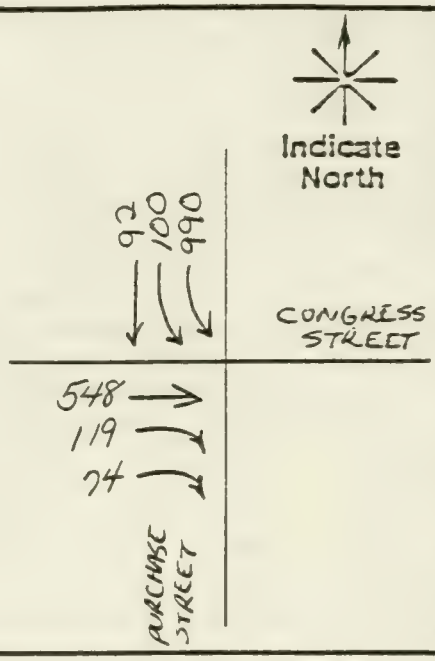
INTERSECTION PURCHASE & CONGRESS ST.
ALT. Existing YEAR 1986 PERIOD A.M.
CALCULATED BY RAR DATE 5-28-86 SHEET 1
CHECKED BY _____ DATE _____ JOB NO. _____
Rev. 10/14/86

INTERSECTION GEOMETRY





Left Turn Che

	Accon 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
T T T T 213 260	T T T T 105 209 309	274 274 193		LT ADV = 16 SEC / 90 SEC CYCLE
				ASSUME 3 SEC. START UP + 2 SEC. / VEH = 13 SEC OR 6.5 VEH / CYCLE 40 CYCLES/HR = 260 V
CLV= 260	CLV= 309	CLV= 274	CLV=	CLV=

Note · 30% reduction in 2 ϕ criteria due to pedestrians

Σ CLV 843
V/C .80
LOS C

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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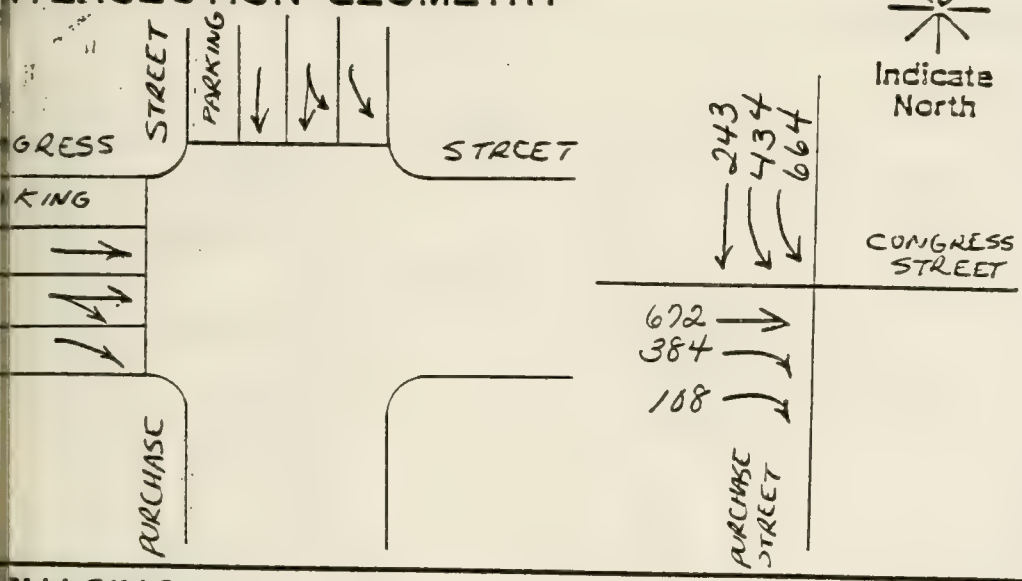
INTERSECTION PURCHASE & CONGRESS STREET
ALT. Existing YEAR 1989 PERIOD P.M.
CALCULATED BY RAR DATE 5-28-86 SHEET 2 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489
Rev. 10/14/86

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
213 260	243 314 314	388 → 284, 388 → 104, 388		LT ADV = 16 SEC / 90 SEC CYCLE
				ASSUME 3 SEC. START UP + 2 SEC. / VEH = 13 SEC OR 6.5 VEH / CYCLE 10 CYCLES/HR = 260 VEH.
CLV= 260	CLV= 314	CLV= 388	CLV=	CLV=

Note: 30% reduction in 2 ϕ criteria due to pedestrians

Σ CLV 962
V/C .92
LOS E

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

(#15)

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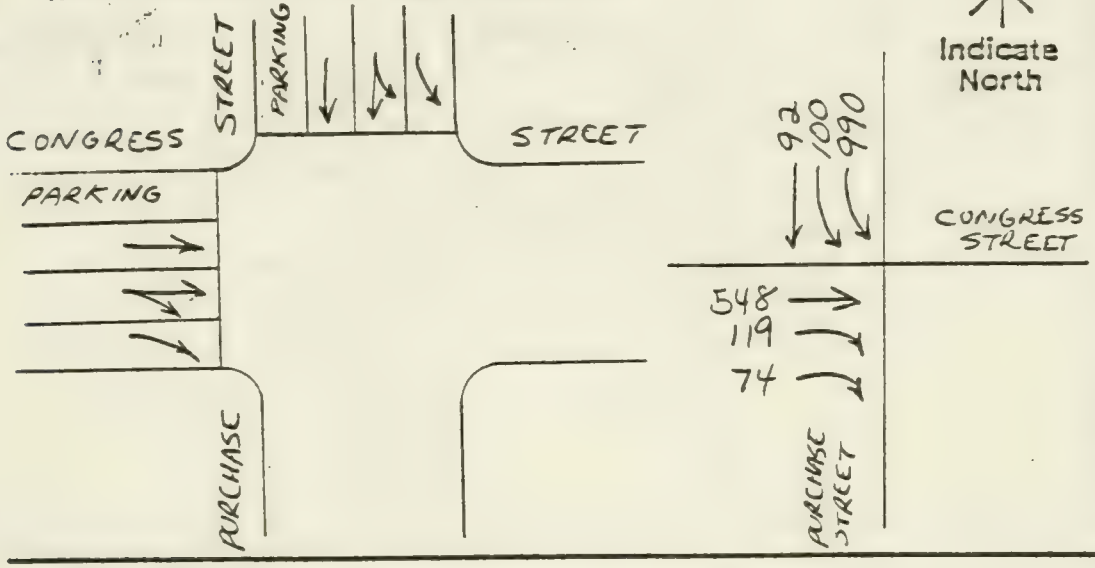
INTERSECTION PURCHASE & CONGRESS STA
ALT. No Build YEAR 1989 PERIOD A.M
CALCULATED BY RAR DATE 5-28-86 SHEET 3 O
CHECKED BY _____ DATE _____ JOB NO. 418

INTERSECTION GEOMETRY



Left Turn Chec

	Accro 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > 0)?		

PHASING

(A)	(B)	(C)	(D)	(E)
213 260	92 308 309	274 274 193		LT ADV = 16 SEC / 90 SEC CYCLE
				ASSUME 3 SEC. START UP + 2 SEC. / VEH = 13 SEC OR 6.5 VEH / CYCLE 40 CYCLES/HR = 260 V
CLV= 260	CLV= 309	CLV= 274	CLV=	CLV=

Note · 30% reduction in 2 ϕ criteria due to pedestrians

Σ CLV 843
V/C .80
LOS C

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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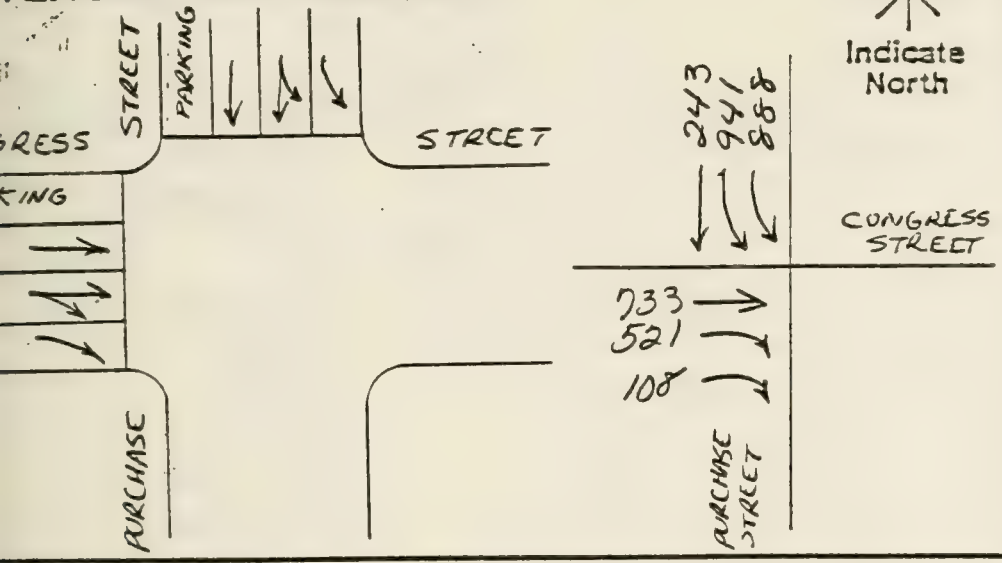
INTERSECTION PURCHASE & CONGRESS STREET
ALT. No Build YEAR 1989 PERIOD P.M.
CALCULATED BY RAR DATE 5-28-86 SHEET 4 OF 6
CHECKED BY _____ DATE _____ JOB NO. 4149
Rev. 10/14/86

TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

A	B	C	D	E
213 260	243 678 678 454	454 279 175 454		LT ADV = 16 SEC / 90 SEC CYCLE
				ASSUME 3 SEC. START UP + 2 SEC. / VEH = 13 SEC OR 6.5 VEH / CYCLE 40 CYCLES/HR = 260 VEH.
CLV= 260	CLV= 678	CLV= 454	CLV=	CLV=

Note: 30% reduction in 2 ϕ criteria due to pedestrians

Σ CLV 1392
V/C 1.32
LOS F

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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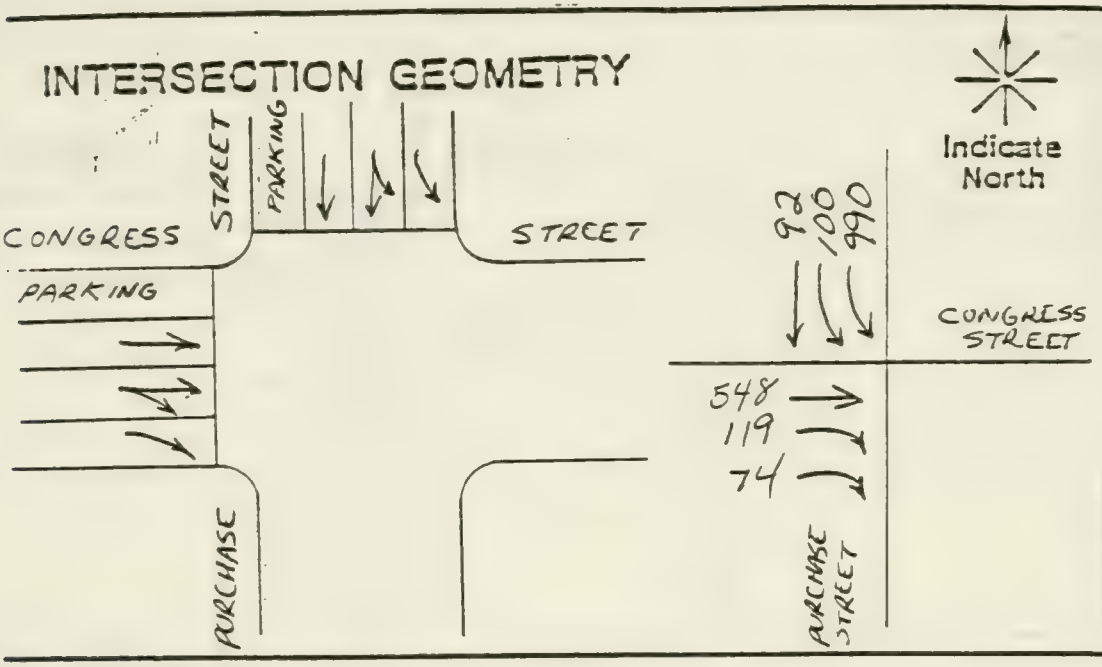
INTERSECTION PURCHASE & CONGRESS STA
ALT. Build YEAR 1989 PERIOD A.M
CALCULATED BY RAR DATE 5-28-86 SHEET 5 C
CHECKED BY _____ DATE _____ JOB NO. LAK
Rev 10/14/86

INTERSECTION GEOMETRY



Left Turn Che

	Accep 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
213 260	92 308 309	274 274 193		LT ADV = 16 SEC / 90 SEC CYCLE
				ASSUME 3 SEC. START UP + 2 SEC. / VEH = 13 SEC OR 6.5 VEH / CYCLE 40 CYCLES/HR = 260 V
CLV= 260	CLV= 309	CLV= 274	CLV=	CLV=

Note · 30% reduction in 2 ϕ criteria due to pedestrians

Σ CLV 843
V/C .80
LOS C

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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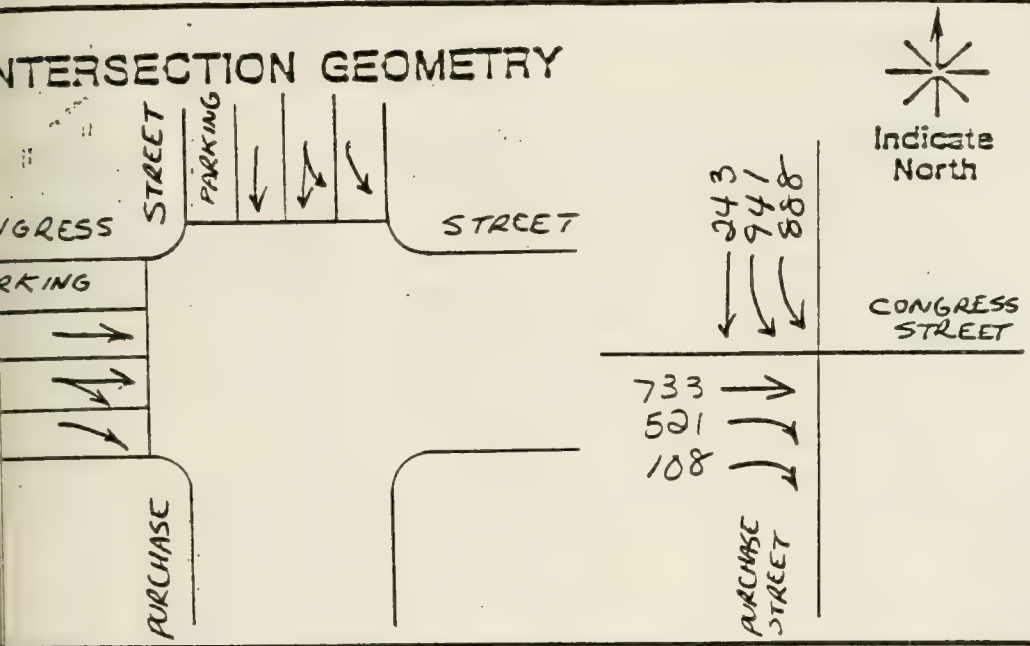
INTERSECTION PURCHASE & CONGRESS STREET
ALT. Build YEAR 1989 PERIOD PM.
CALCULATED BY RAR DATE 5-28-86 SHEET 6 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489
Rev 10/14/86

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
213 260	243 678 678	454 279 175 454		LT ADV = 16 SEC / 90 SEC CYCLE
				ASSUME 3 SEC. START UP + 2 SEC. / VEH = 13 SEC OR 6.5 VEH / CYCLE
				40 CYCLES/HR = 260 VEH.
CLV= 260	CLV= 678	CLV= 454	CLV=	CLV=

Note: 30% reduction in 2 ϕ criteria due to pedestrians

Σ CLV 1392
V/C 1.32
LOS F

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

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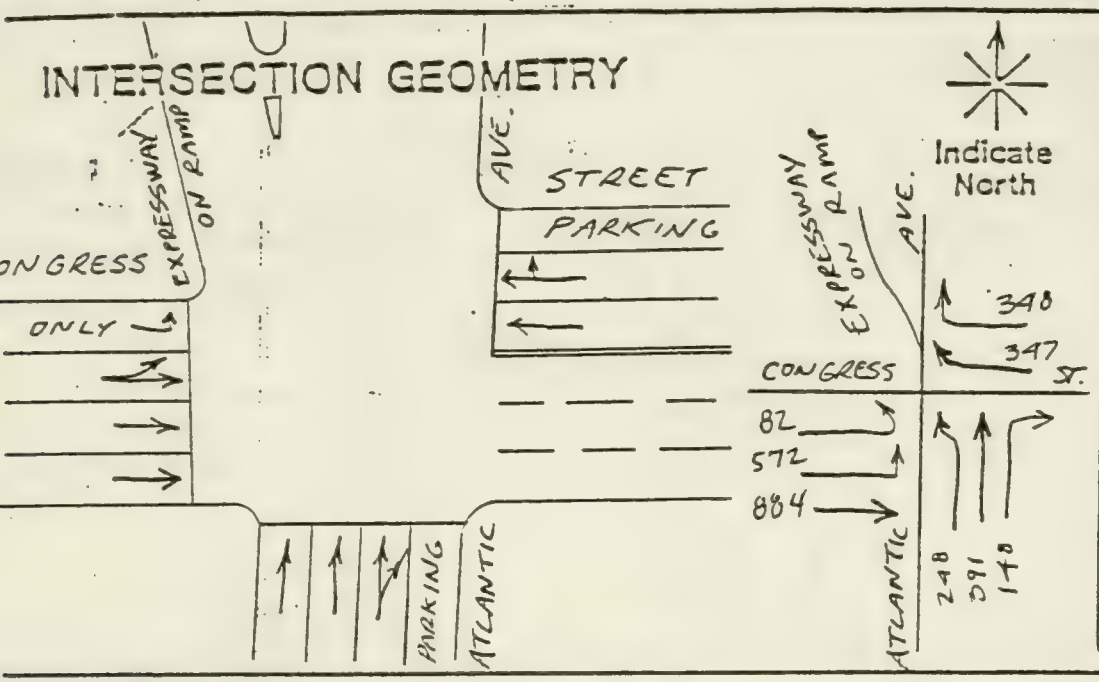
ALT. EXISTING YEAR 1986 PERIOD A.M
CALCULATED BY RAR DATE 5-23-86 SHEET 1 C
CHECKED BY _____ DATE _____ JOB NO. 14

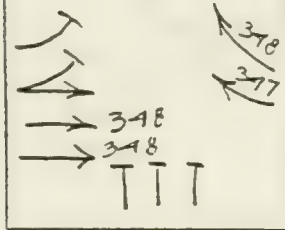
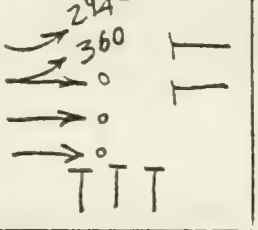
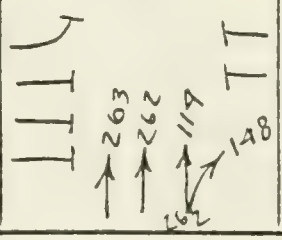
INTERSECTION GEOMETRY



Left Turn Chec

	Approa 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
				
CLV= 348	CLV= 454	CLV= 263	CLV=	CLV=

Note: 10% reduction in 3Ø criteria due to pedestrians

Σ CLV 1065
V/C .83
LOS D

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1282

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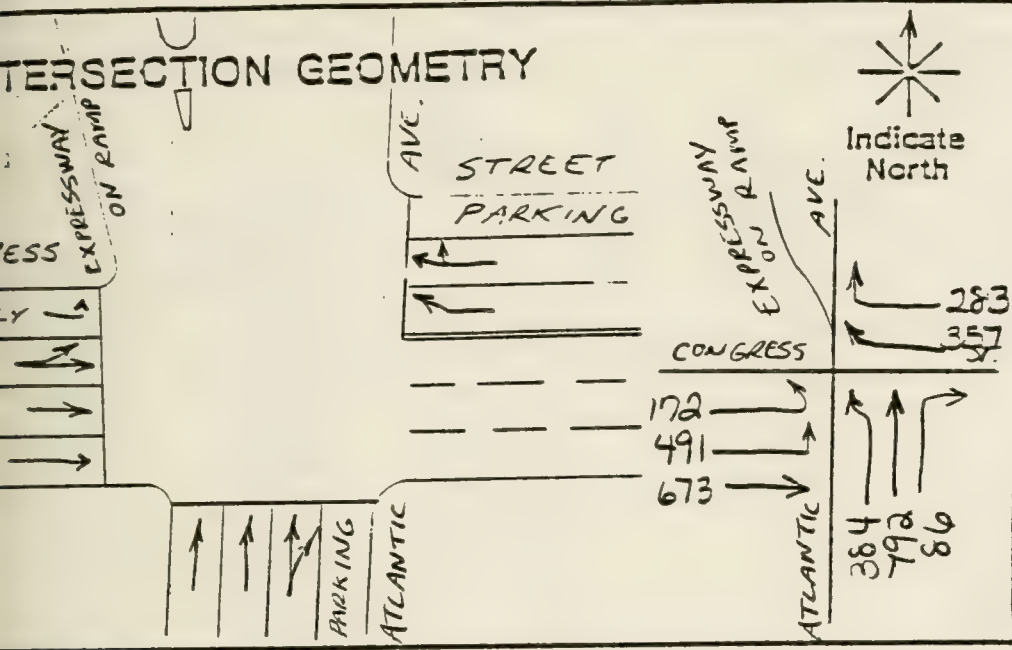
INTERSECTION CONGRESS & ATLANTIC
ALT. Existing YEAR 1986 PERIOD PM
CALCULATED BY RAR DATE 5/23/86 SHEET 2 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489
Rev. 10/14/86

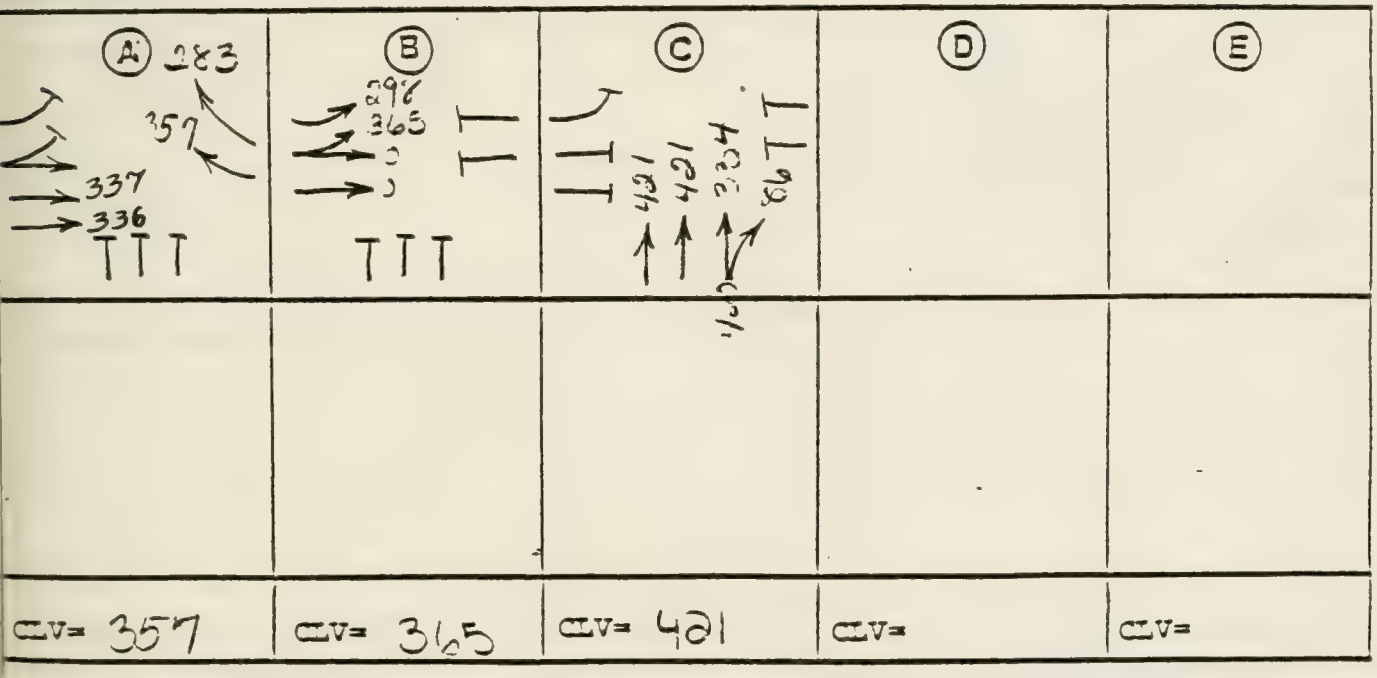
TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING



CLV= 357 | CLV= 365 | CLV= 421 | CLV= | CLV=

Note: 10% reduction in 3Ø criteria due to pedestrians

Σ CLV 1143
V/C .89
LOS D

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

232

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INTERSECTION CONGRESS & ATLANTIC
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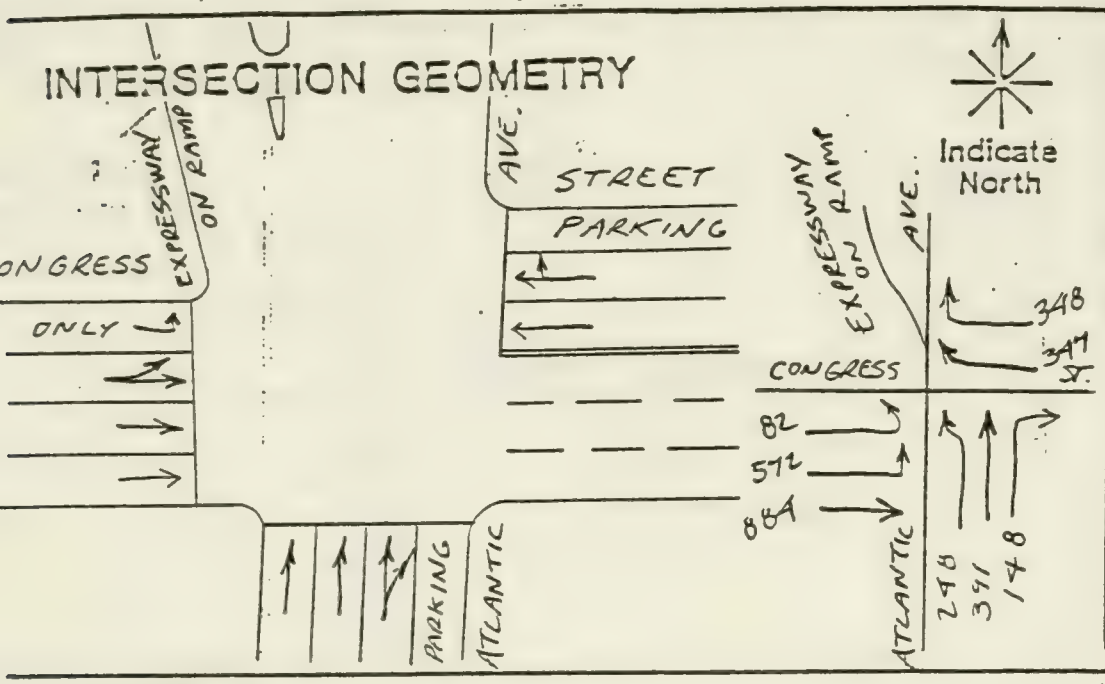
CALCULATED BY RAR DATE 5-23-86 SHEET 3
CHECKED BY _____ DATE _____ JOB NO. 14

INTERSECTION GEOMETRY



Left Turn Che

	Accon 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
348, 347, 348, 348	294, 360, 454, 94, 94	263, 262, 292, 114, 196		
CLV= 348	CLV= 454	CLV= 263	CLV=	CLV=

Note: 10% reduction in 3Ø criteria due to pedestrians

Σ CLV 1065
V/C .83
LOS D

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1282

(#16)

3

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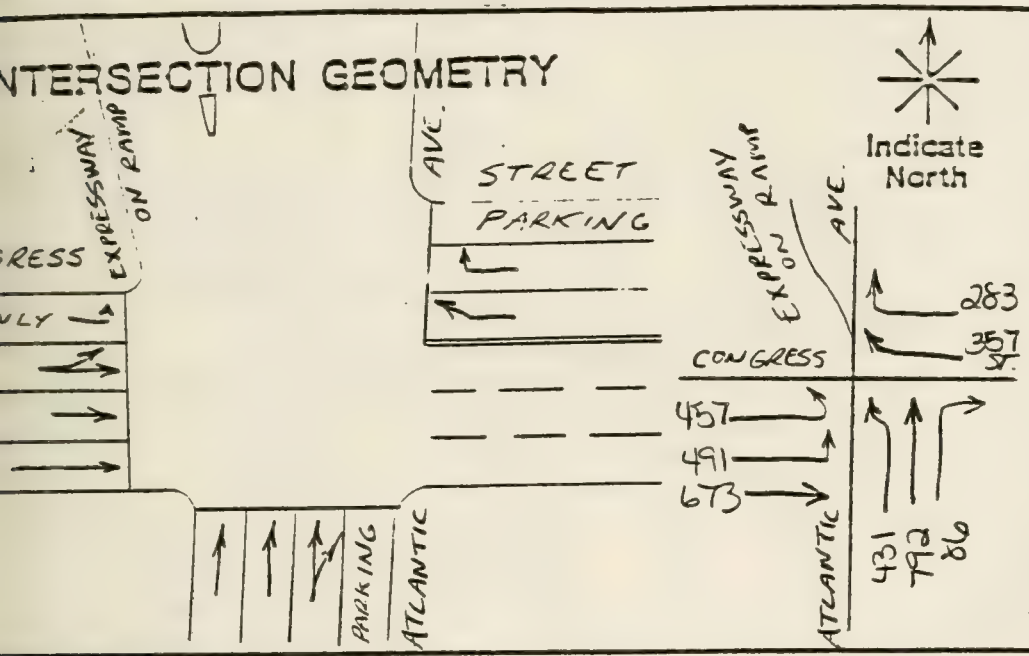
INTERSECTION CONGRESS & ATLANTIC
ALT. No Build YEAR 1987 PERIOD P.M.
CALCULATED BY RAR DATE 5/23/86 SHEET 4 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1287
Rev 10/14/86

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > 0)?				

PHASING

A	B	C	D	E
283, 357, 337, 336	427, 521	437, 436, 350, 86, 436		
CLV= 357	CLV= 521	CLV= 437	CLV=	CLV=

Note: 10% reduction in 3Ø criteria due to pedestrians

Σ CLV 1315
V/C 1.02
LOS F

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

12.32

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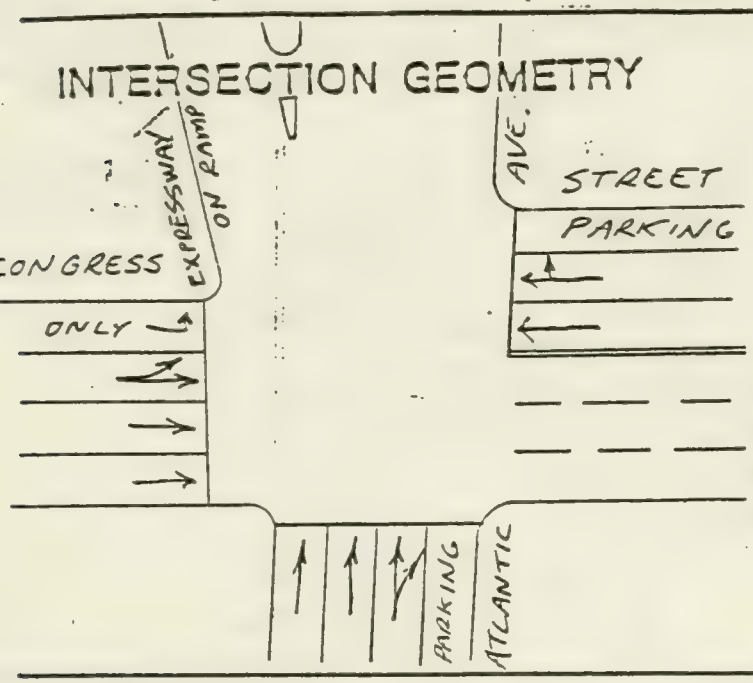
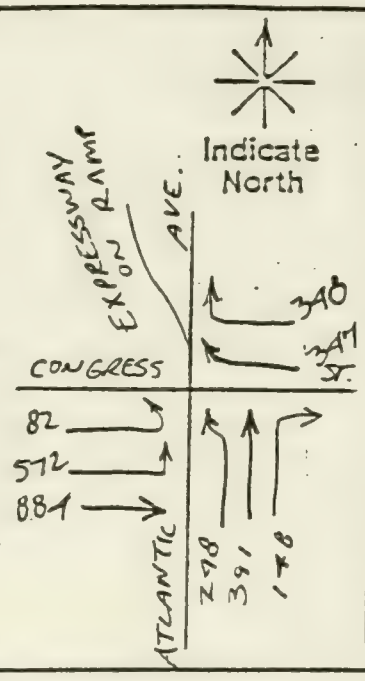
INTERSECTION CONGRESS & ATLANTIC
ALT. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-23-86 SHEET 5
CHECKED BY _____ DATE _____ JOB NO. 14

INTERSECTION GEOMETRY

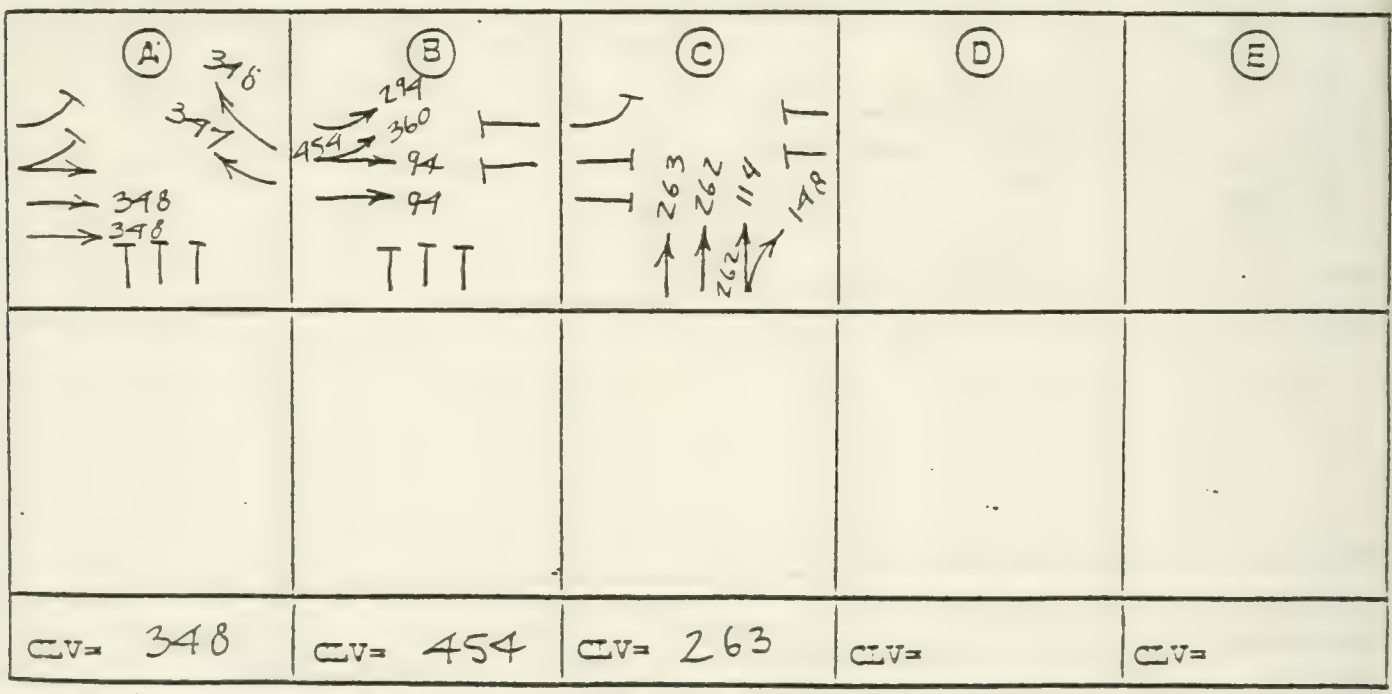




Left Turn Che

	Accn 1	Accn 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING



CLV= 348	CLV= 454	CLV= 263	CLV=	CLV=

Note: 10% reduction in 3Ø criteria due to pedestrians

Σ CLV 1065
V/C .83
LOS D

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

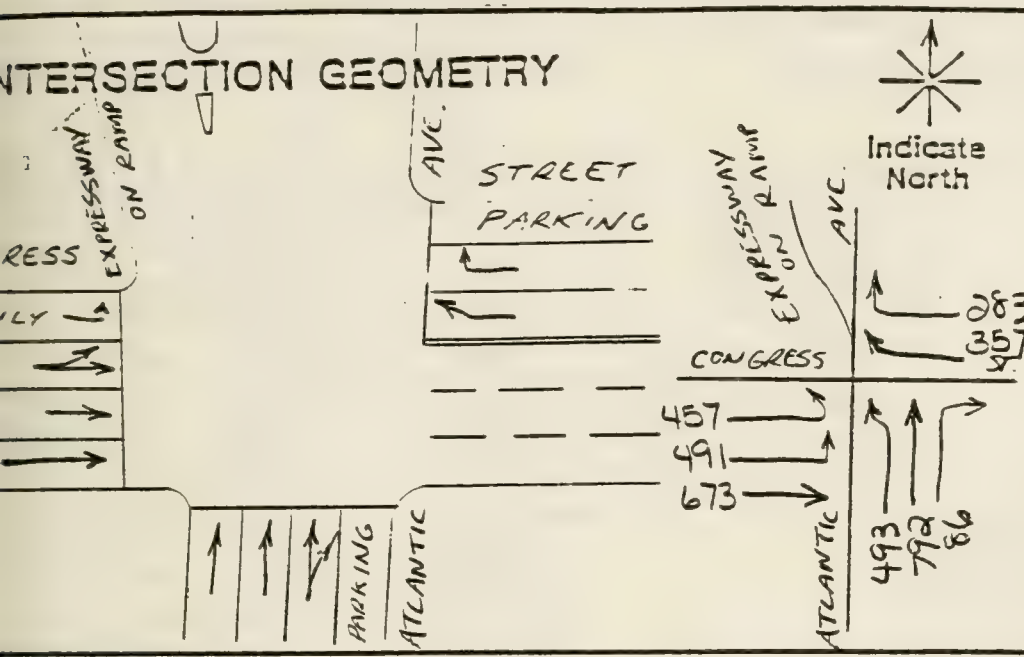
1282

(#16)

asse/Hangen Engineering, Inc.
sulting Engineers & Planners
irmingham Parkway, Boston, MA 02135
783-7000

INTERSECTION CONGRESS & ATLANTIC
ALT. Build YEAR 1987 PERIOD P.M.
CALCULATED BY RAR DATE 5/22/86 SHEET 6 OF 6
CHECKED BY _____ DATE _____ JOB NO. 12 97
Rev. 10/14/86

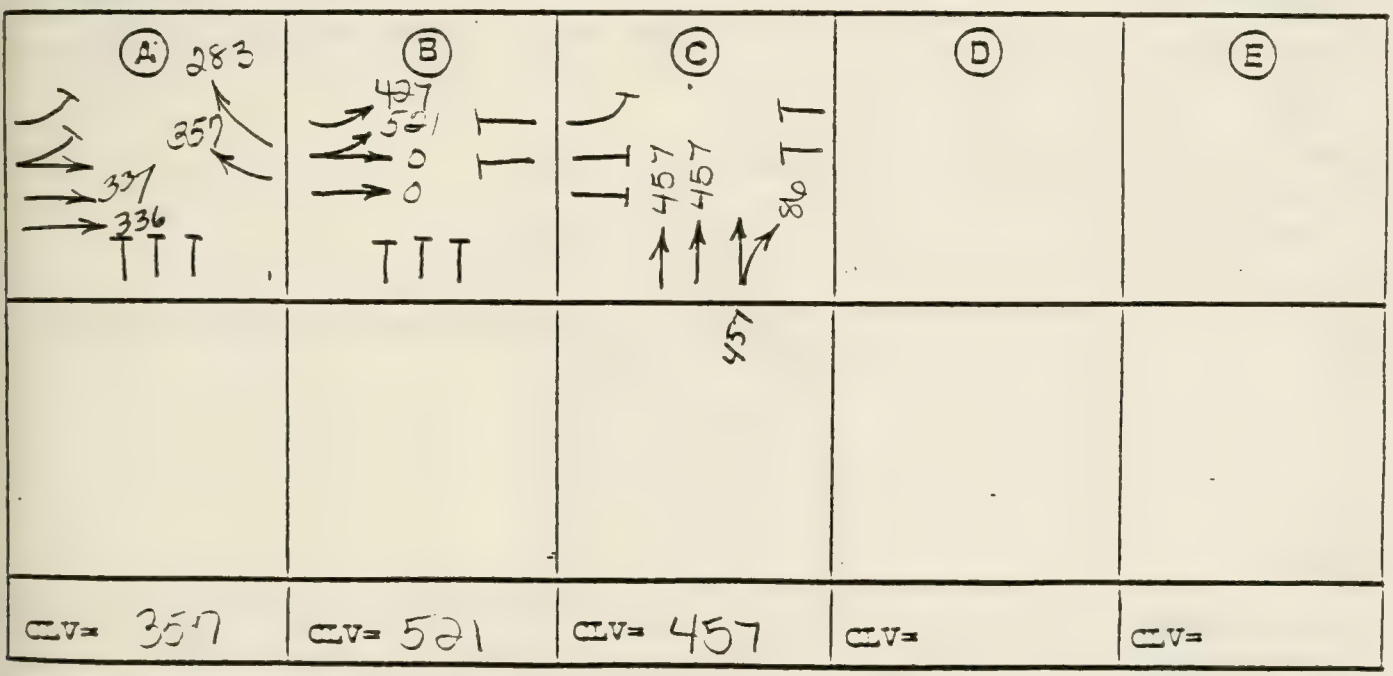
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING



CLV= 357	CLV= 521	CLV= 457	CLV=	CLV=

Note: 10% reduction in 3Ø criteria due to pedestrians

Σ CLV 1335
V/C 1.04
LOS F

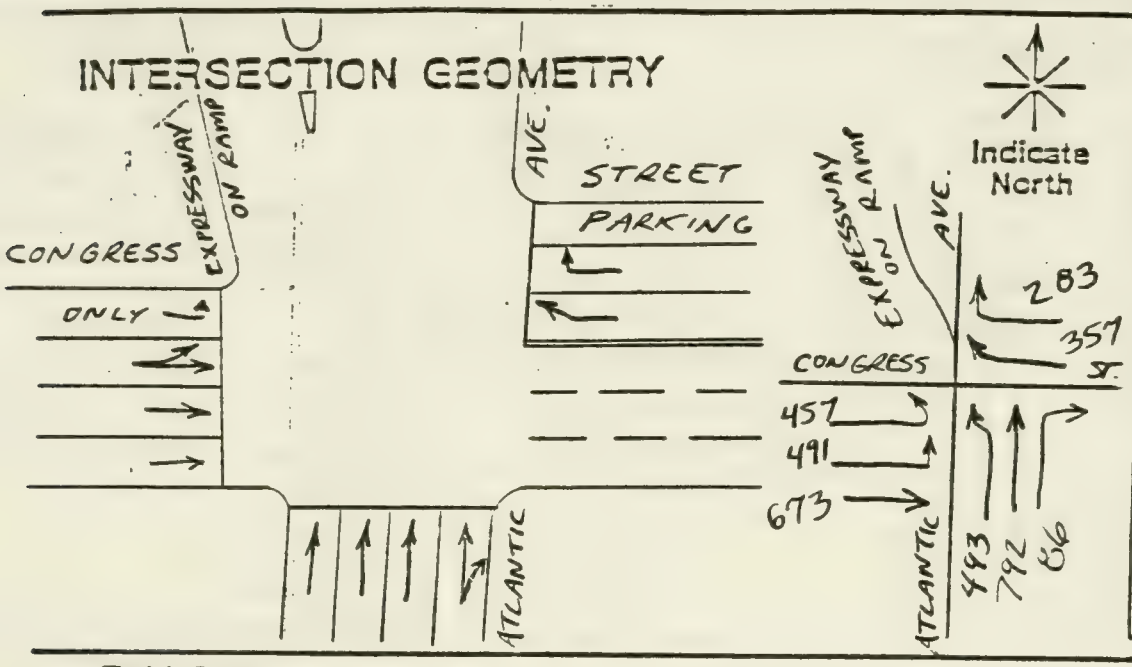
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

(#16)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION CONGRESS & ATLANTIC
ALT. MITIGATION YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 12-11-86 SHEET 1
CHECKED BY _____ DATE _____ JOB NO. 1

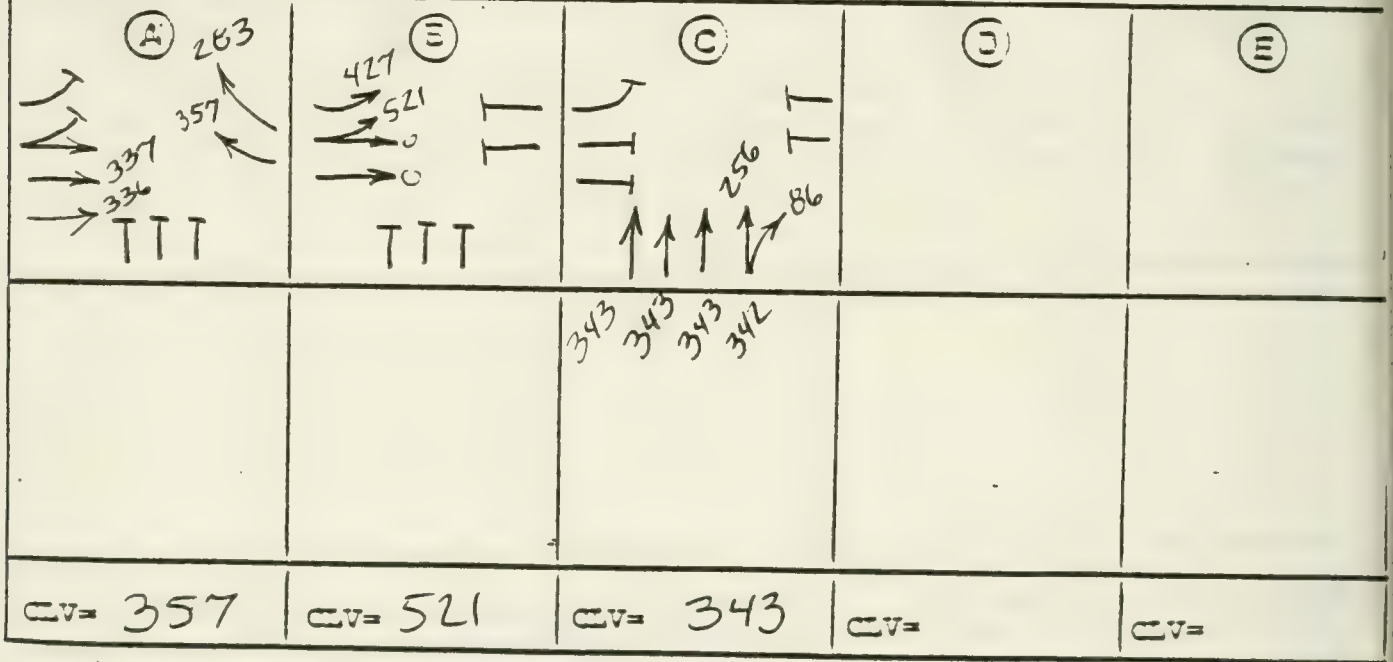
INTERSECTION GEOMETRY



Left Turn C

	Ac 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING



CV= 357	CV= 521	CV= 343	CV=	CV=

Note: 10% reduction in 3Ø criteria due to pedestrians

Σ CLV 1221
V/C 0.95
LOS E

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

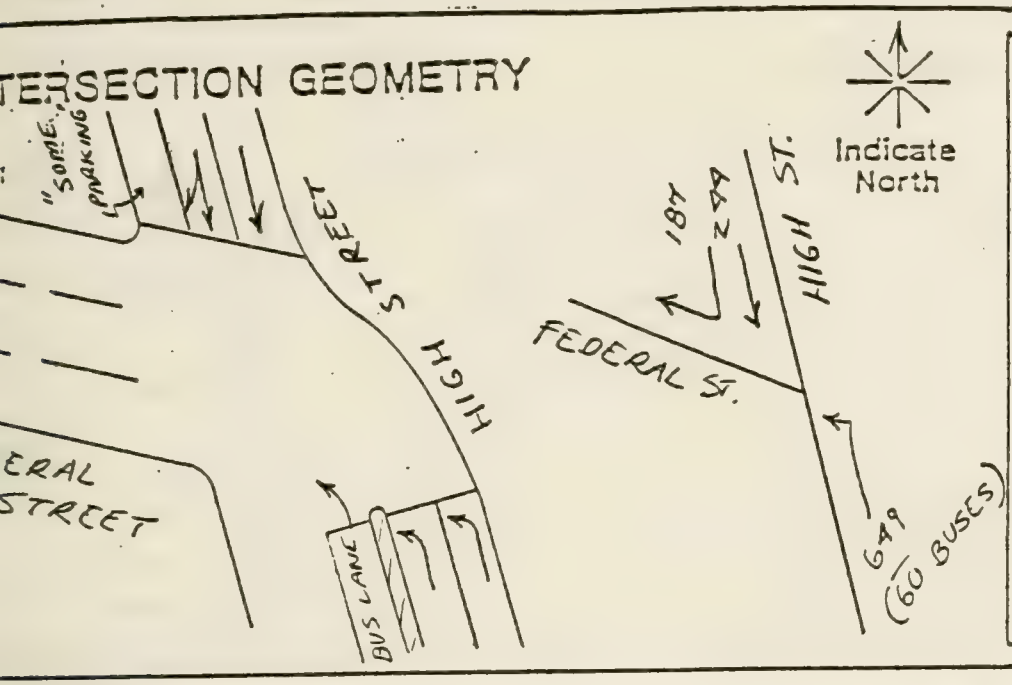
1282

(#13)

sse/Hangen Engineering, Inc.
ting Engineers & Planners
ningham Parkway, Boston, MA 02135
3-7000

INTERSECTION HIGH STREET / FEDERAL STREET
ALT. EXISTING YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-29-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
87 244 T T	324 265	60		
		BUS VOLUMES x 2 = PASS. CAR EQUIV		
CLV= 244	CLV= 324	CLV= 120	CLV=	CLV=

NOTE: 30% reduction in 2 Ø criteria due to pedestrians

Σ CLV 688
V/C .66
LOS B

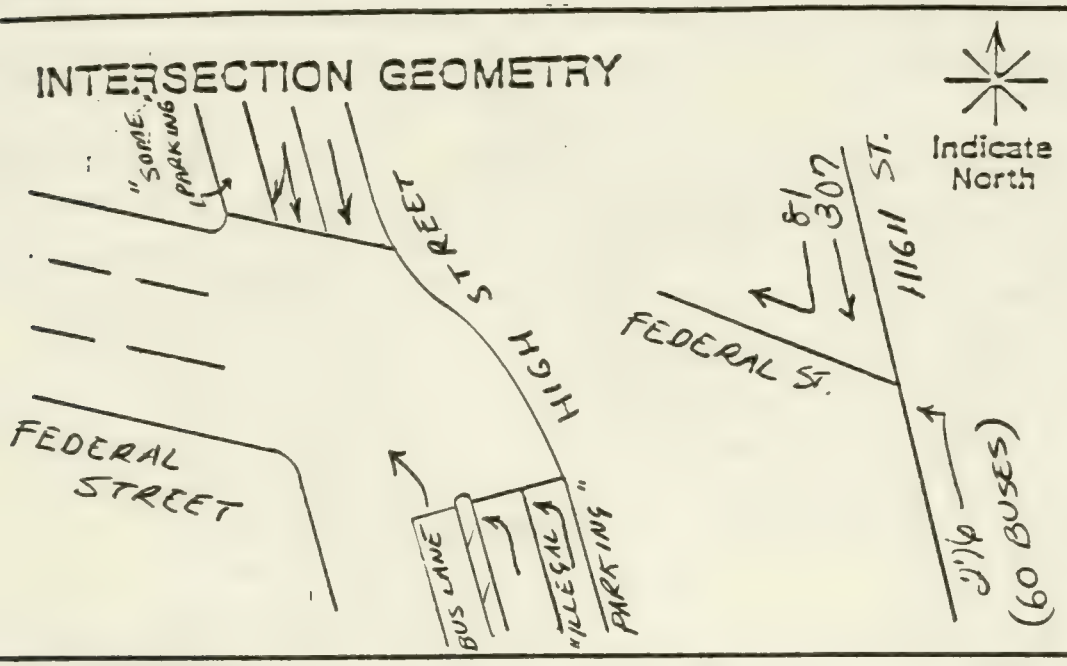
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

VHB (#13)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION HIGH STREET / FEDERAL ST
ALT. Existing YEAR 1986 PERIOD PM
CALCULATED BY RAR DATE 5-29-86 SHEET 2 OF
CHECKED BY _____ DATE _____ JOB NO. 148
Rev 10/14/86

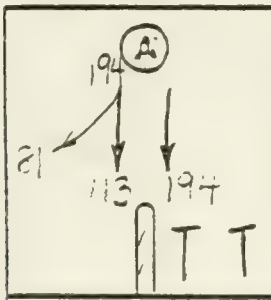
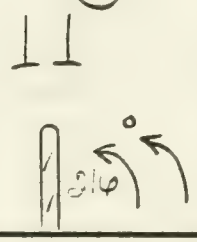
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	Approach 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
				
		Bus volumes X2 = Pass Car equiv.		
CLV= 194	CLV= 216	CLV= 120	CLV=	CLV=

NOTE: 30% reduction in 2 Ø criteria due to pedestrians

Σ CLV 530
V/C .50
LOS A

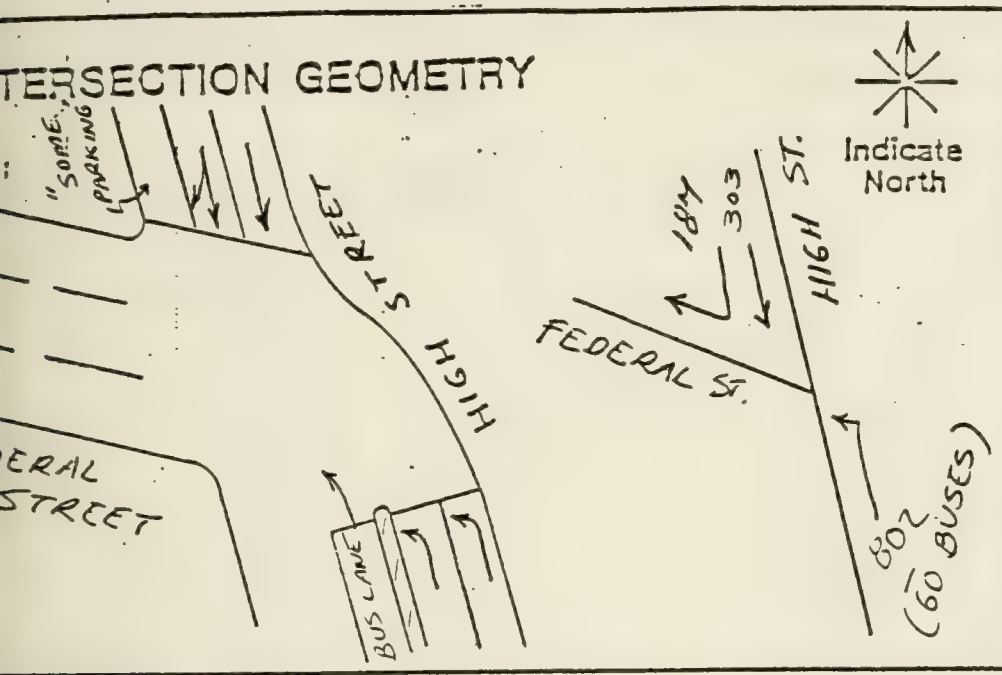
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

(#13)

sse/Hangen Engineering, Inc.
lting Engineers & Planners
mingham Parkway, Boston, MA 02135
23-7000

INTERSECTION HIGH STREET / FEDERAL STREET
ALT. NO. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-29-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

(A)	(B)	(C)	(D)	(E)
87 ↙ 303 ↓ T T	401 ↑ 341 ↑	60 ↑		
		BUS VOLUMES X 2 = PASS. CAR EQUIV.		
CLV= 303	CLV= 401	CLV= 120	CLV=	CLV=

NOTE: 30% reduction in 2 Ø criteria due to pedestrians

Σ CLV 824
V/C .78
LOS C

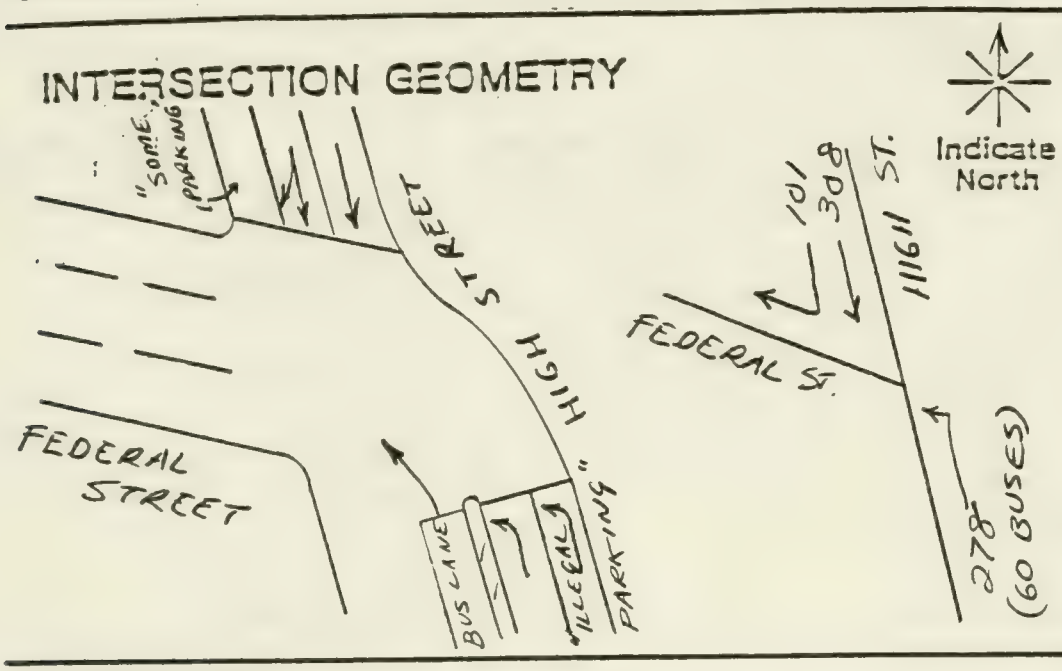
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

VH-9 (#13)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION HIGH STREET / FEDERAL ST
ALT. No Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 6-29-86 SHEET 4 O
CHECKED BY _____ DATE _____ JOB NO. 114
Rev. 10/14/86

INTERSECTION GEOMETRY



Left Turn Chec

	Accre 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
204 → 101, 103, 205	210	60		
		Bus Volumes ×2 = Pass. Car Equiv.		
CLV= 205	CLV= 218	CLV= 120	CLV=	CLV=

NOTE: 30% reduction in 2 Ø criteria due to pedestrians

Σ CLV 543
V/C .52
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

nasse/Hangen Engineering, Inc.
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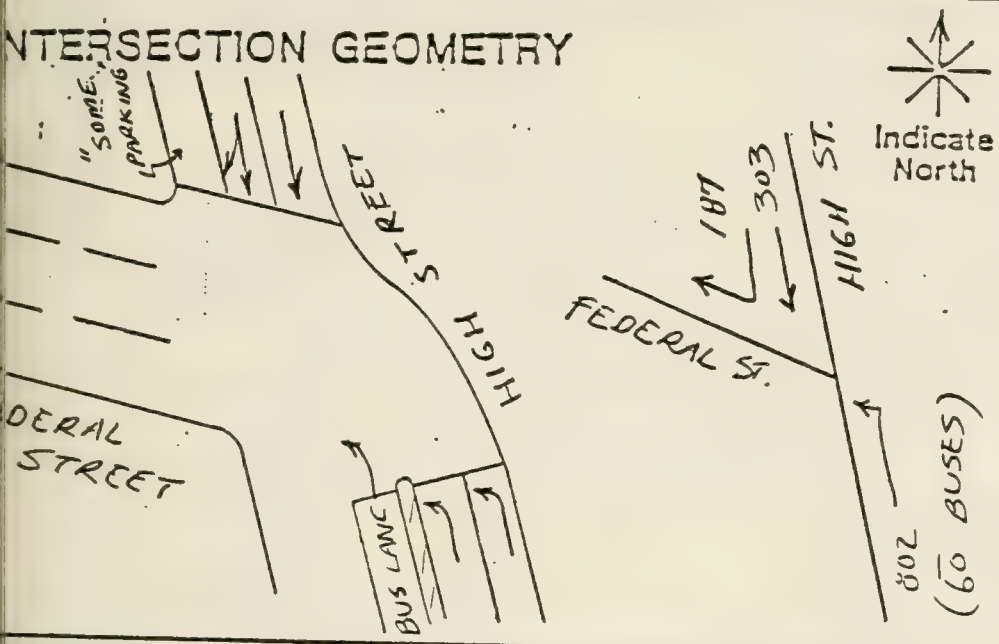
Birmingham Parkway, Boston, MA 02135
/783-7000

INTERSECTION HIGH STREET / FEDERAL STREET
ALT. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-29-86 SHEET 5 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

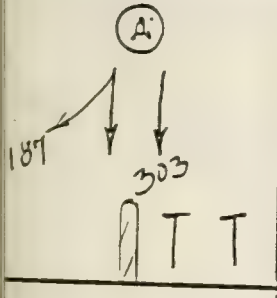
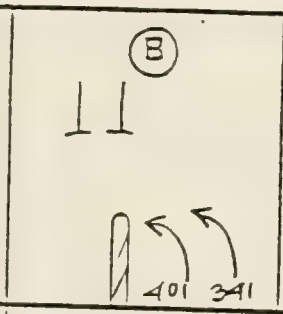
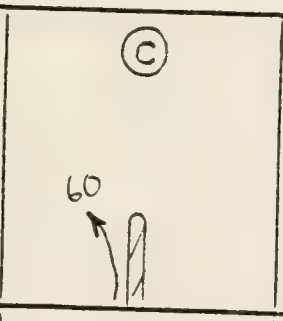
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

A	B	C	D	E
				
		BUS VOLUMES x 2 = PASS. CAR EQUIV.		
CLV= 303	CLV= 401	CLV= 120	CLV=	CLV=

NOTE: 30% reduction in 2 Ø criteria due to pedestrians

Σ CLV 824
V/C .78
LOS C

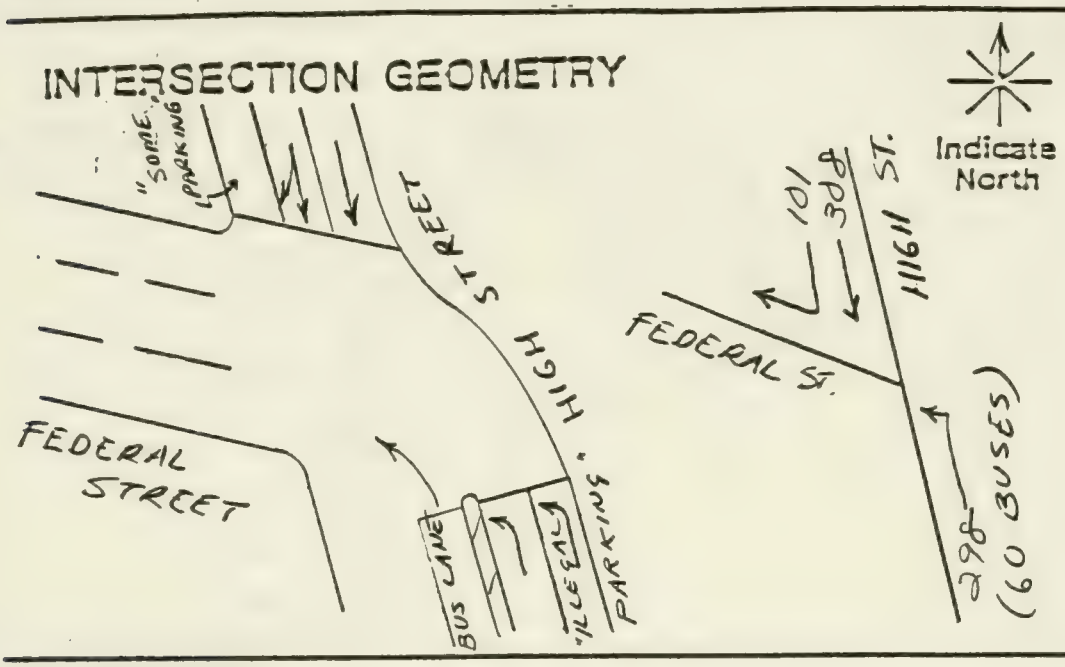
CRITERIA (vch)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

VH (#13)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION HIGH STREET / FEDERAL ST
ALT. Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5-29-86 SHEET 10 OF
CHECKED BY _____ DATE _____ JOB NO. 14.
Rev 10/14/86

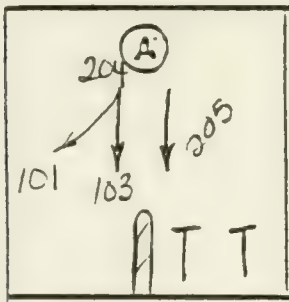
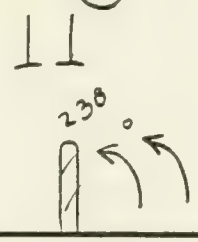
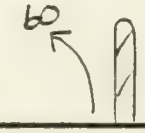
INTERSECTION GEOMETRY



Left Turn Che

	Accom 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
				
CLV= 205	CLV= 238	CLV= 120	CLV=	CLV=

NOTE: 30% reduction in 2 Ø criteria due to pedestrians

Σ CLV 563
V/C .54
LOS A

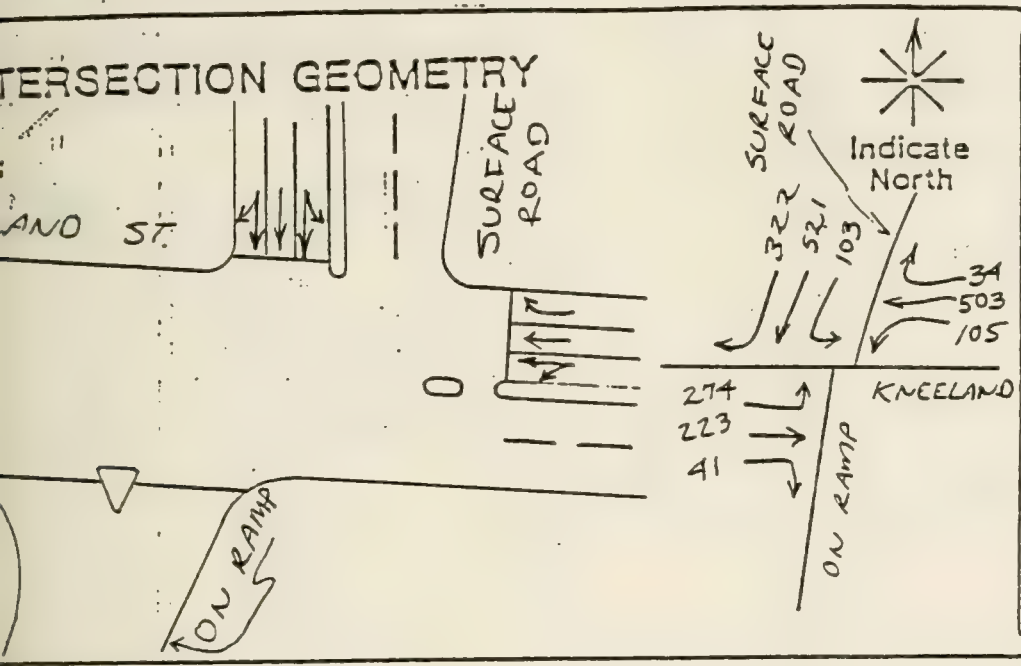
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

(#3)

sse/Hangen Engineering, Inc.
ling Engineers & Planners
ningham Parkway, Boston, MA 02135
3-7000

INTERSECTION KNEELAND / SURFACE ROAD / ON RA.
ALT. EXISTING YEAR 1986 PERIOD A.M.
CALCULATED BY RAR DATE 5-27-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

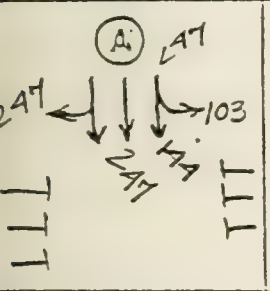
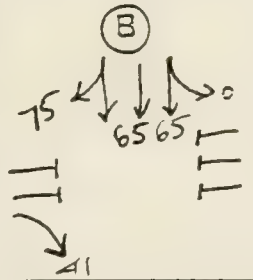
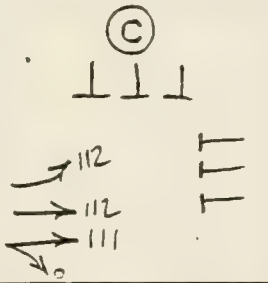
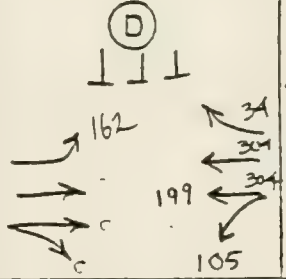
TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
				LEAD PHASE A = 14 sec / 80 sec = .45 cycles/hour
	use min value of 100 for CLV		162 + 304 = 466	assume 3 sec start up + 2 sec/veh 11 sec or 5.5 veh/cycle 45 cycle/hour = 247 veh
CLV= 247	CLV= 100	CLV= 112	CLV= 466	CLV=

NOTE: 23.75% reduction in 3Ø criteria due to pedestrians in A.M.
19 % " " " " " " " " P.M.

Σ CLV 925
V/C .85
LOS D

CRITERIA (veh)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

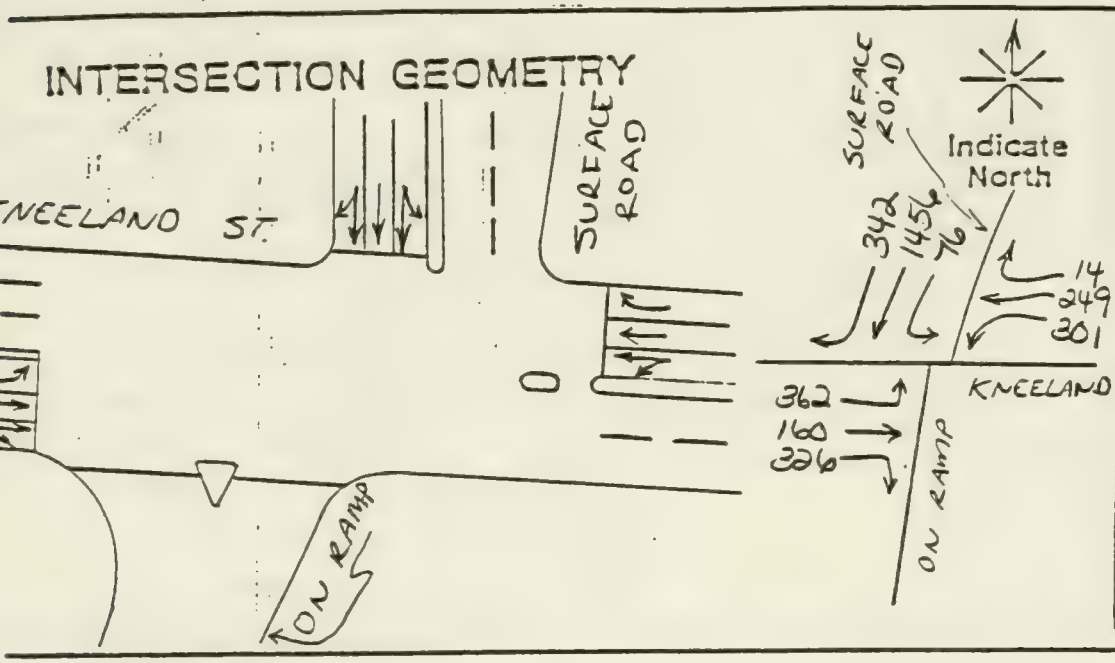
1085

(#3)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION KNEELAND / SURFACE ROAD / O
ALT. Existing YEAR 1986 PERIOD PM
CALCULATED BY RAR DATE 5/28/86 SHEET 2 C
CHECKED BY _____ DATE _____ JOB NO. 14
Rev 10/14/86

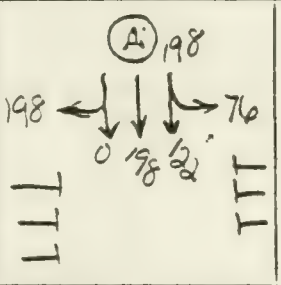
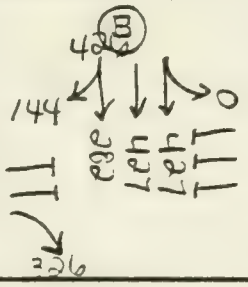
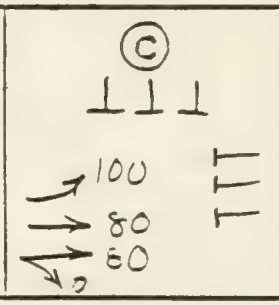
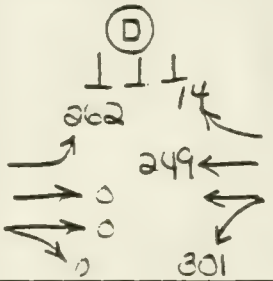
INTERSECTION GEOMETRY



Left Turn Che

	Accon 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. C/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
				LEAD PHASE A= 14 sec / 100 sec = 36 cycles/hr
		use min CLV value of 100	249 + 262 = 511	assume 3 sec start up + 2 sec / 11 sec at 5.5 veh / 36 cycles/hr = 198
CLV= 198	CLV= 427	CLV= 100	CLV= 511	CLV=

NOTE: 23.75% reduction in 3Ø criteria due to pedestrians in
19 7. " " " " " " " " F

Σ CLV 1236
V/C 1.07
LOS F

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1155

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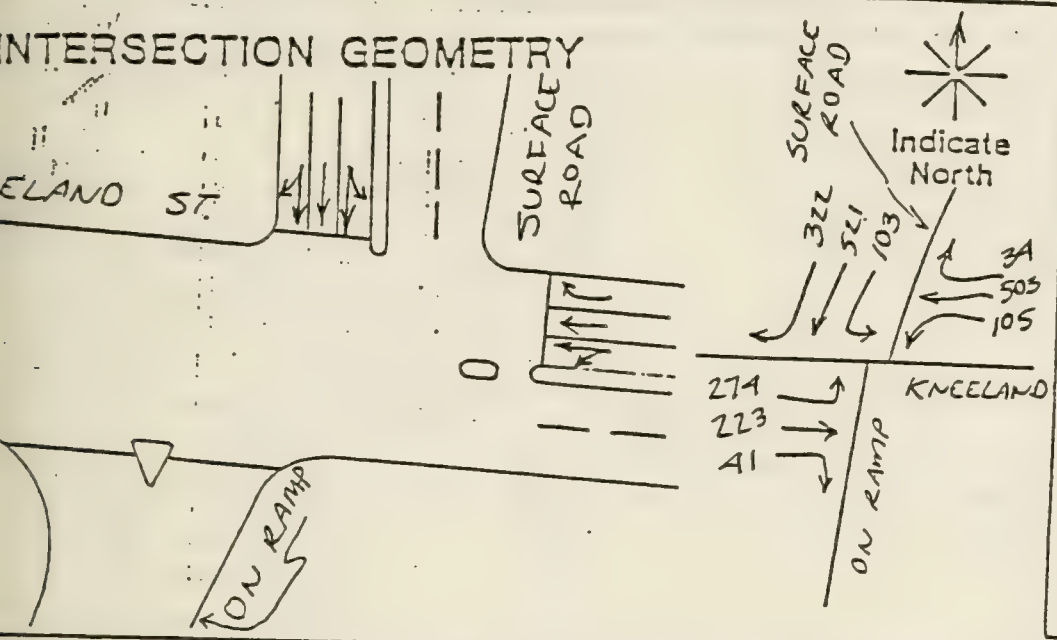
7/783-7000

INTERSECTION KNEELAND / SURFACE ROAD / ON R
ALT. NO. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-28-86 SHEET 3 OF
CHECKED BY _____ DATE _____ JOB NO. 1489

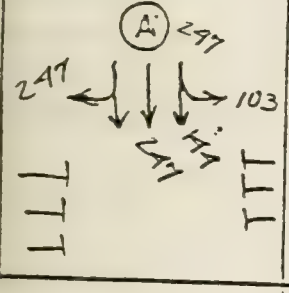
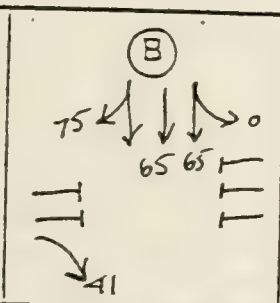
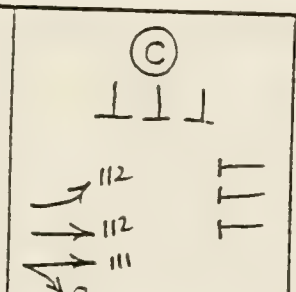
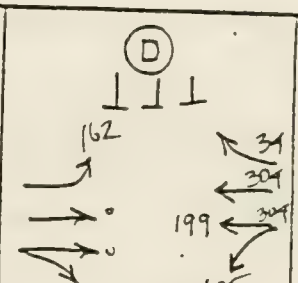
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
				LEAD PHASE A= 14 sec / 80 sec = 45 cycles/hour
	use min value of 100 for CLV		162 + 304 = 466	assume 3 sec start up + 2 sec/veh 11 sec @ 5.5 veh/cyc 45 cycles/hour = 2
CLV= 247	CLV= 100	CLV= 112	CLV= 466	CLV=

NOTE: 23.75% reduction in 3Ø criteria due to pedestrians in A.M.
19 % " " " " " " " P.M.

Σ CLV 925
V/C .85
LOS D

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1085

(#3)

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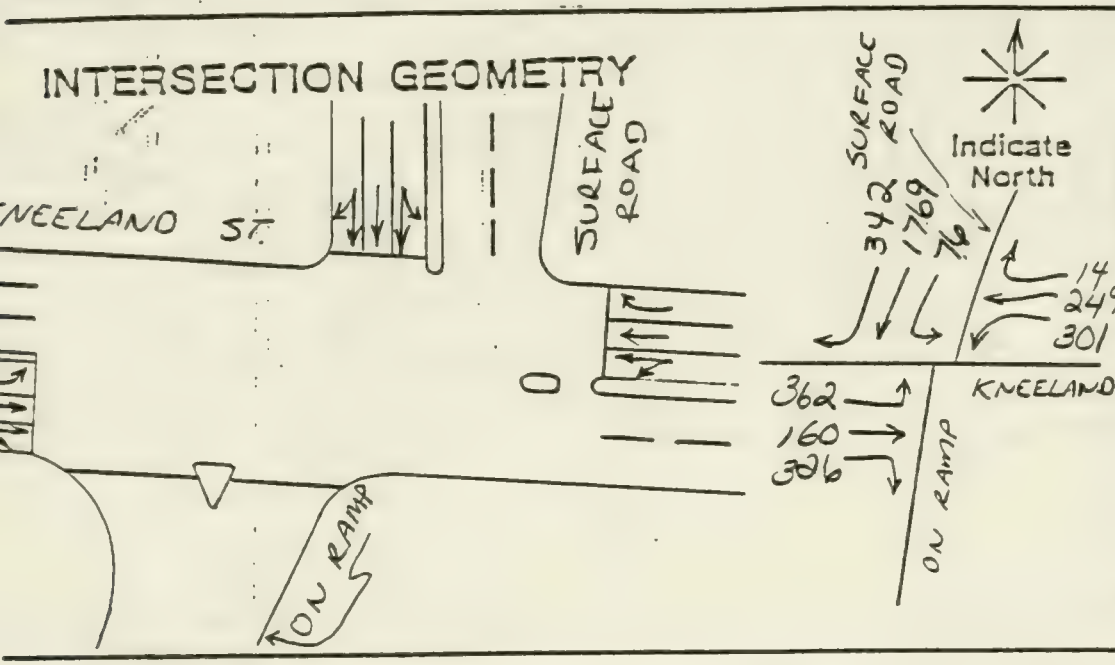
617/783-7000

INTERSECTION KNEELAND / SURFACE ROAD / O.
ALT. No Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5/22/86 SHEET 4
CHECKED BY _____ DATE _____ JOB NO. 14
Rev. 10/14/86

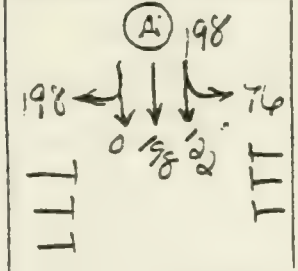
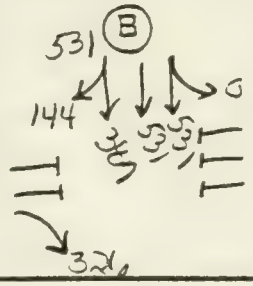
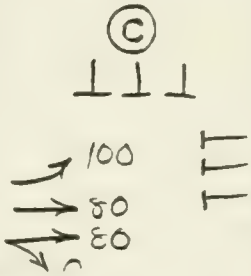
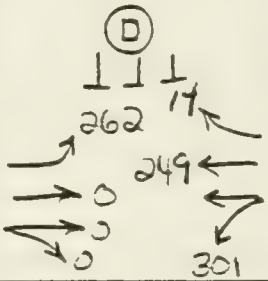
INTERSECTION GEOMETRY



Left Turn Che

	Appr 1	Appr 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
				LEAD PHASE A= 14 sec / 100 sec = 36 cycles/hr
		use min CLV value of 100	262 + 249 = 511	assume 3 sec start up + 2 sec / 11 sec at 5.5 veh / 36 cycles/hr = 198
CLV= 198	CLV= 531	CLV= 100	CLV= 511	CLV=

NOTE: 23.75% reduction in 3Ø criteria due to pedestrians in
19 7. " " " " " " " " " " "

Σ CLV 1340
V/C 1.16
LOS F

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1155

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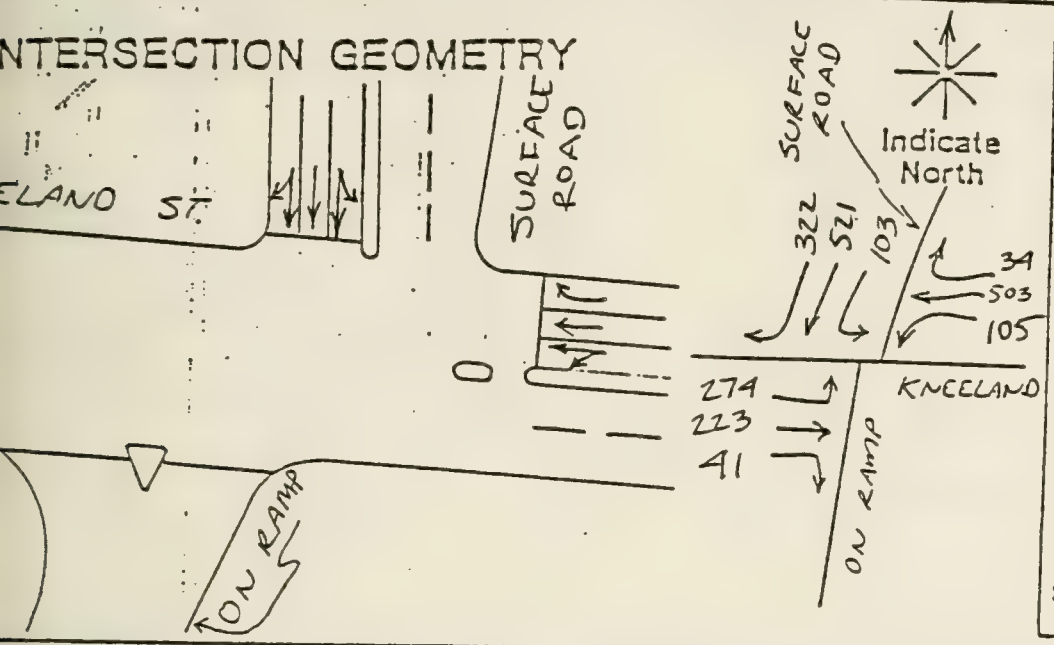
INTERSECTION KNEELAND / SURFACE ROAD / ON R.
ALT. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-28-86 SHEET 5 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

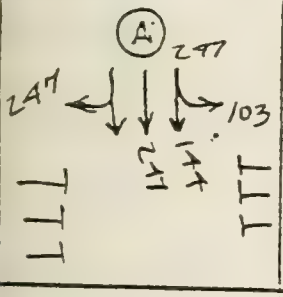
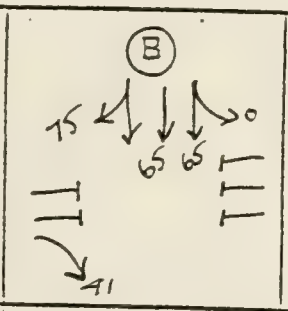
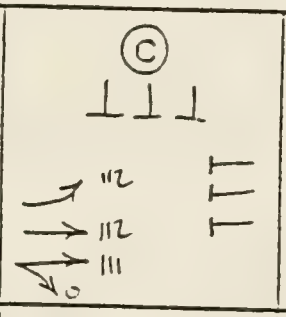
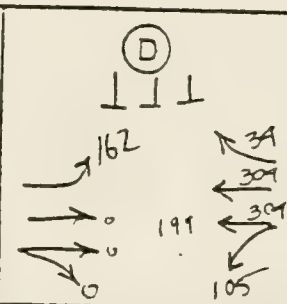
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
				LEAD PHASE A= 14 sec / 80 sec = 45 cycles/hour
	use min CLV value of 100		162 + 304 = 466	assume 3 sec start up + 2 sec/veh 11 sec @ 5.5 veh/cyc 45 cycles/hour = 2
CLV= 247	CLV= 100	CLV= 112	CLV= 466	CLV=

NOTE: 23.75% reduction in 3Ø criteria due to pedestrians in A.M.
19 % " " " " " " " " P.M.

Σ CLV 925
V/C .85
LOS D

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1085

VA (#3)

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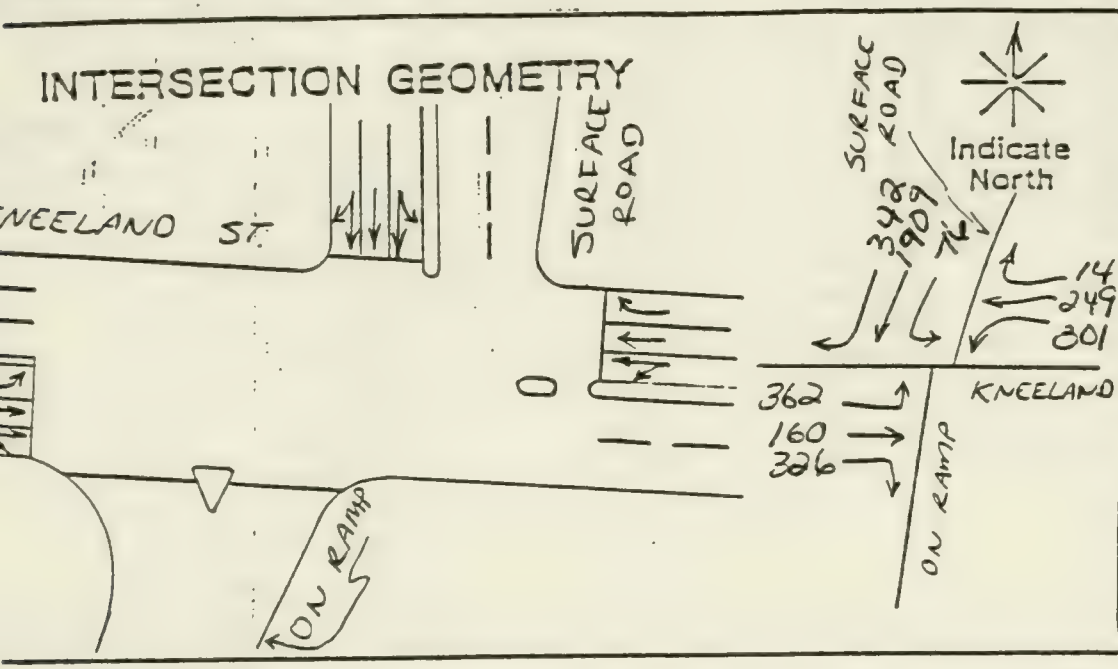
INTERSECTION KNEELAND / SURFACE ROAD / O
ALT. Build YEAR 1987 PERIOD PM
CALCULATED BY RAR DATE 5/28/86 SHEET 6
CHECKED BY _____ DATE _____ JOB NO. 1
Rev. 10/14/86

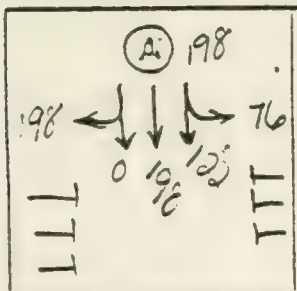
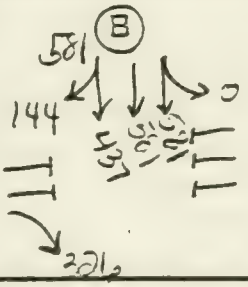
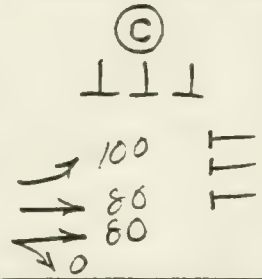
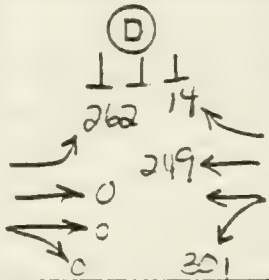
INTERSECTION GEOMETRY



Left Turn Che

	Accep 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
				LEAD PHASE A= 14 sec / 100 sec = 36 cycles/hr
		ind min CLV value of 100	262 + 249 = 511	assume 3 sec start up + 2 sec / 11 sec or 5.5 sec / 36 cycles/hr = 198 /
CLV= 198	CLV= 581	CLV= 100	CLV= 511	CLV=

NOTE: 23.75% reduction in 3Ø criteria due to pedestrians in
19 % " " " " " " " "

Σ CLV 1390
V/C 1.20
LOS F

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 1155	1375

(#2)

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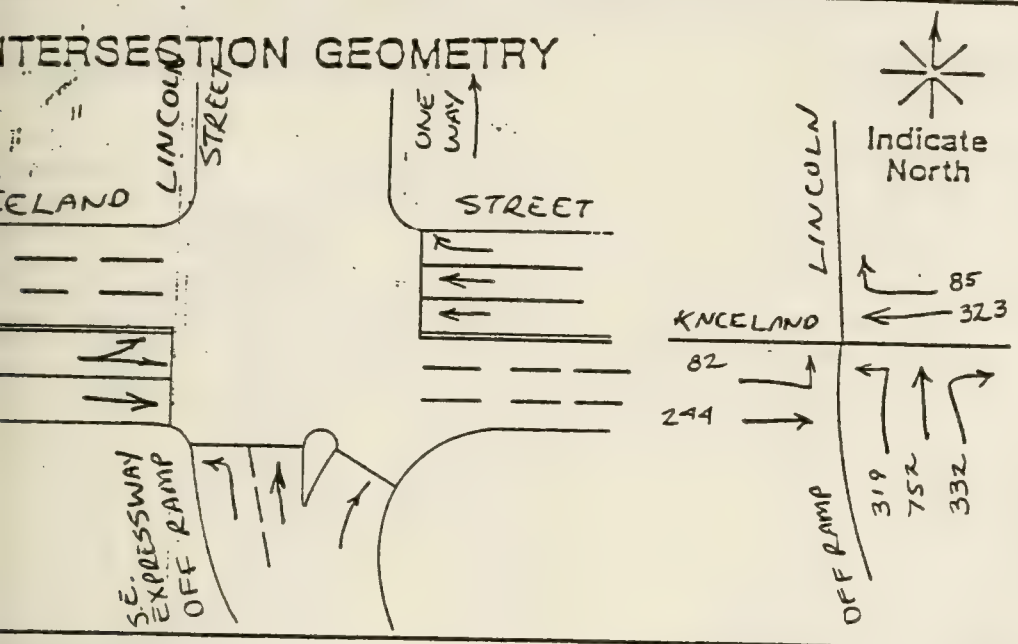
783-7000

INTERSECTION KNCELAND & LINCOLN
ALT. EXISTING YEAR 1986 PERIOD A.M.
CALCULATED BY RAR DATE 5-27-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1484

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
319 216 536 332 536	82 0 100 TTT	0 85 72 119 204 72 204 TTT		
	USE CLV = 100 AS MINIMUM			
CLV= 536	CLV= 100	CLV= 204	CLV=	CLV=

Note: Use 17% reduction in 3ϕ criteria for pedestrians

Σ CLV 840
V/C .71
LOS C

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 1180	1375

(#2)

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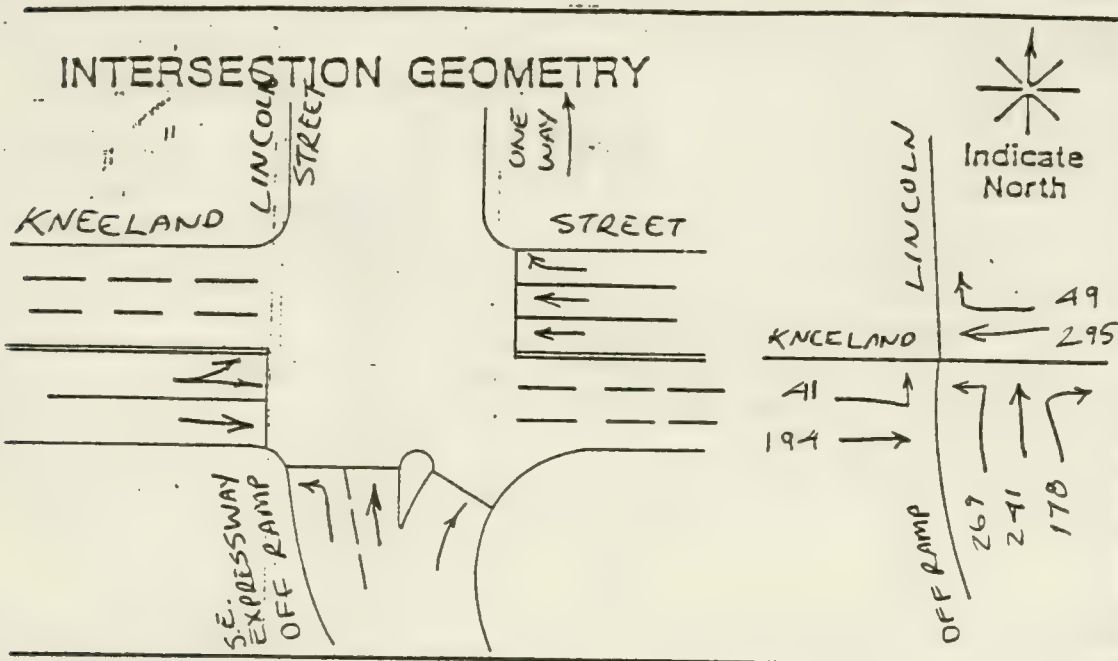
617/783-7000

INTERSECTION KNEELAND & LINCOLN
ALT. EXISTING YEAR 1986 PERIOD P.M.
CALCULATED BY RAR DATE 5-27-86 SHEET 2
CHECKED BY _____ DATE _____ JOB NO. _____

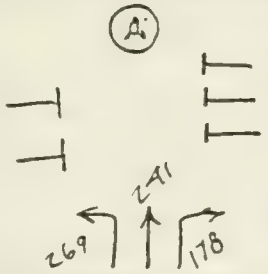
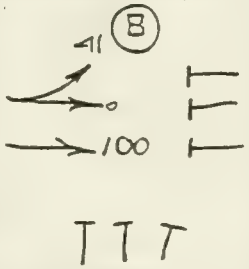
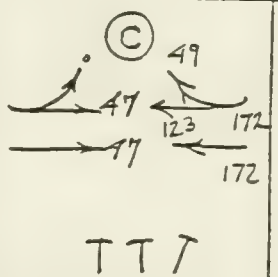
INTERSECTION GEOMETRY



Left Turn Ch

	Acc 1	Acc 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
	 TTT	 TTT		
	USE CLV= 100 AS MINIMUM VALUE			
CLV= 269	CLV= 100	CLV= 172	CLV=	CLV=

Note: Use 17% reduction in 3ϕ criteria for pedestrians

Σ CLV 541
V/C .46
LOS A

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 1180	1375

(#2)

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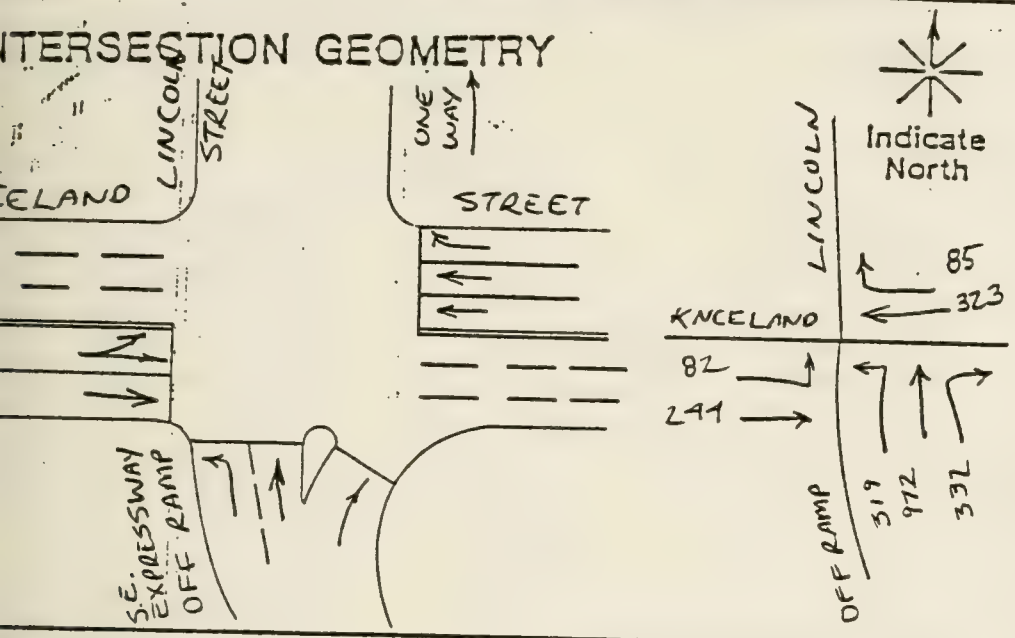
INTERSECTION KNCELAND & LINCOLN
ALT. NO BUILD YEAR 1989 PERIOD A.M.
CALCULATED BY RAR DATE 5-27-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
326, 676, 319, 45, 332	82, 0, 100	0, 85, 72, 204, 72, 119, 204		
	USE CLV = 100 AS MINIMUM VALUE			
CLV= 676	CLV= 100	CLV= 204	CLV=	CLV=

Note: Use 17% reduction in 3ϕ criteria for pedestrians

Σ CLV 950
V/C .81
LOS D

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 1180	1375

VH (#2)

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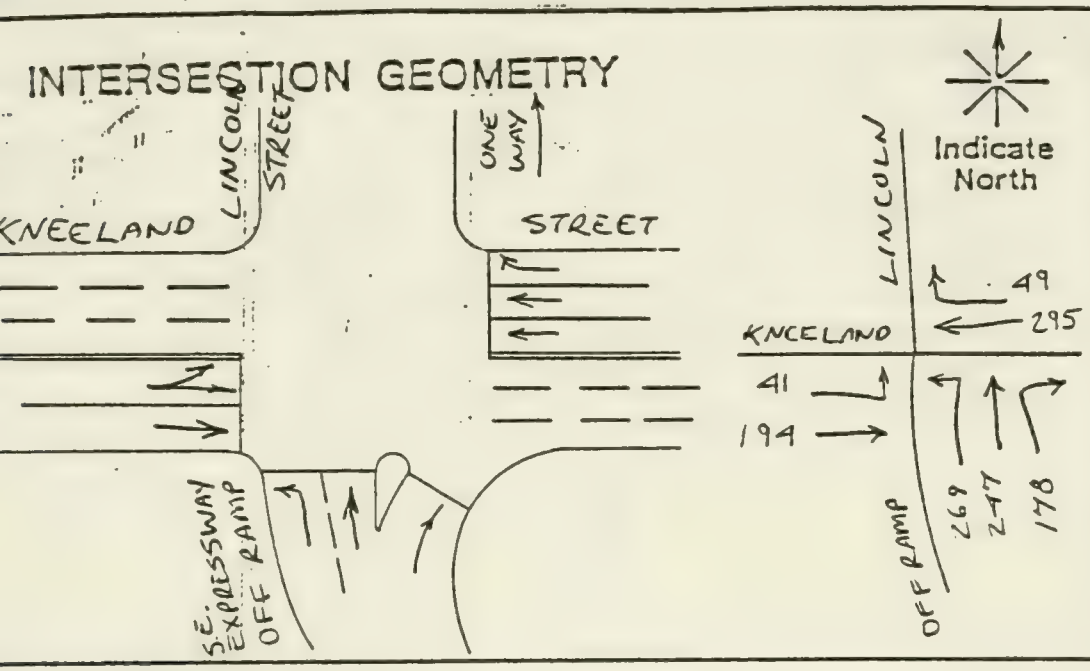
INTERSECTION KNEELAND & LINCOLN
ALT. NO BUILD YEAR 1989 PERIOD P.M.
CALCULATED BY RAR DATE 5-27-86 SHEET 4
CHECKED BY _____ DATE _____ JOB NO. 12

INTERSECTION GEOMETRY



Left Turn Ch

	Appr 1	Appr 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
269 ← 247 ↑ 178 →	41 → 0 / 100 →	0 / 49 → 47 / 47 → 123 ← 172 / 172 ←		
	USE CLV= 100 + 5 MINIMUM VALUE			
CLV= 269	CLV= 100	CLV= 172	CLV=	CLV=

Note: Use 17% reduction in 3Ø criteria for pedestrians

Σ CLV 541
V/C .46
LOS A

CRITERIA (veh)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 1180	1375

(#2)

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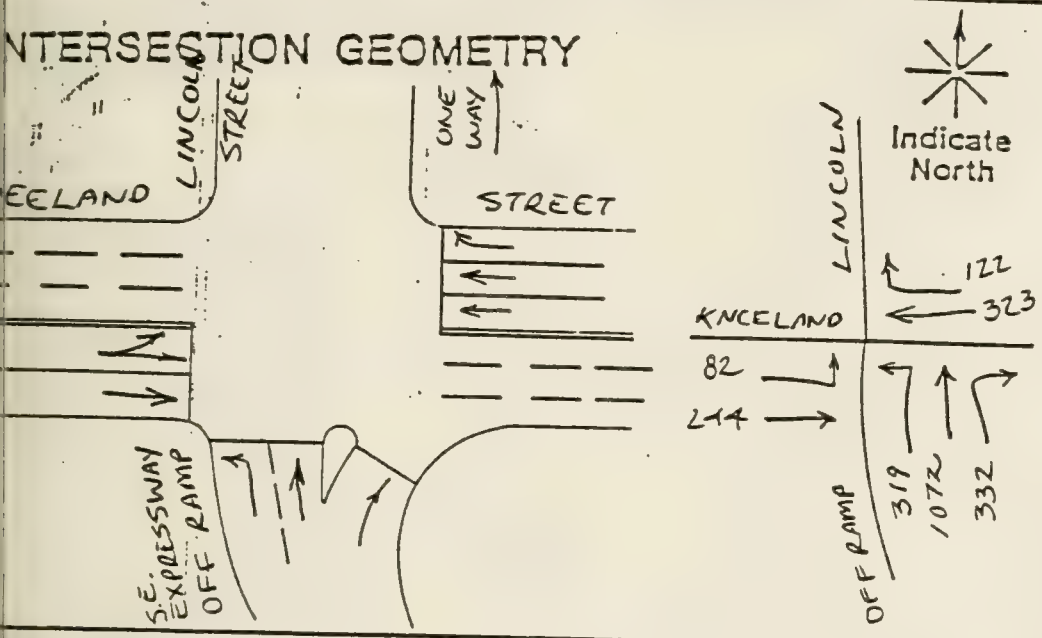
INTERSECTION KNEELAND & LINCOLN
ALT. BUILD YEAR 1989 PERIOD A.M.
CALCULATED BY RAR DATE 5-27-86 SHEET 5 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
376, 319, 696, 696	82, 0, 100	122, 72, 100, 222, 72, 223		
TTT	TTT	TTT		
CLV= 696	CLV= 100	CLV= 223	CLV=	CLV=

Note: Use 17% reduction in 3ϕ criteria for pedestrians

Σ CLV 1019
V/C .86
LOS D

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 1180	1375

(#2)

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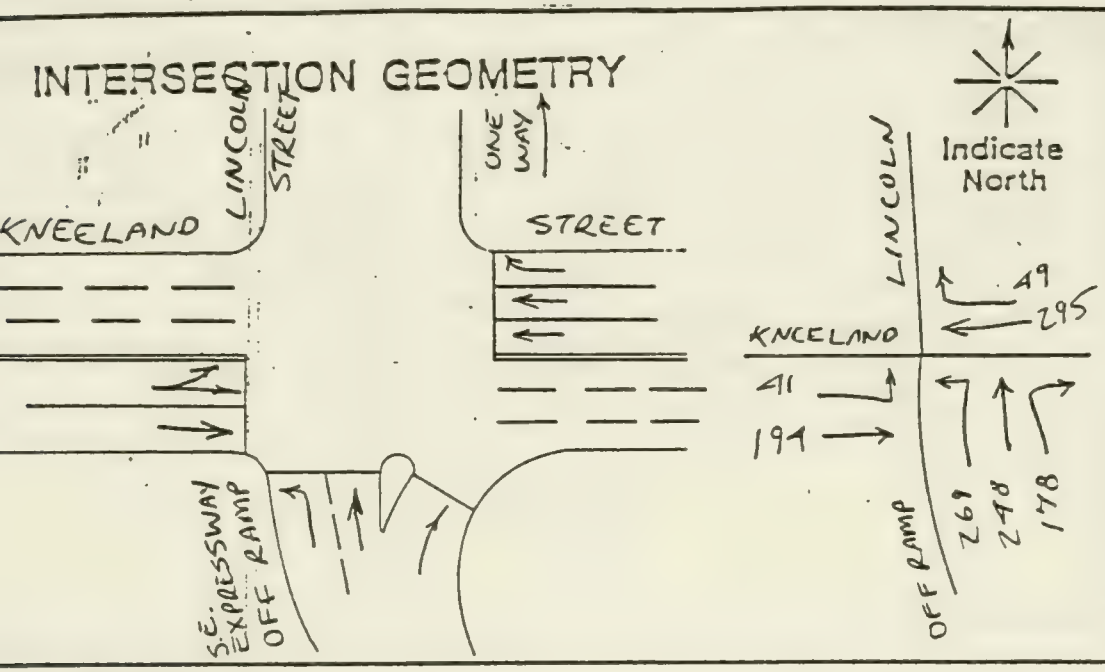
617/783-7000

INTERSECTION KNEELAND & LINCOLN
ALT. BUILD YEAR 1989 PERIOD P.M.
CALCULATED BY RAR DATE 5-27-86 SHEET 6
CHECKED BY _____ DATE _____ JOB NO. 1-1

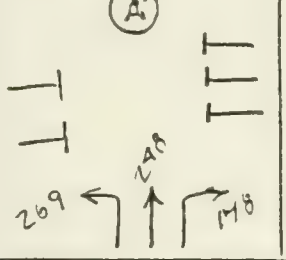
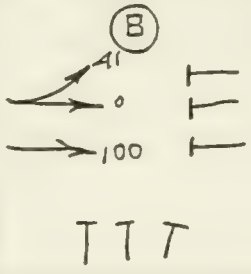
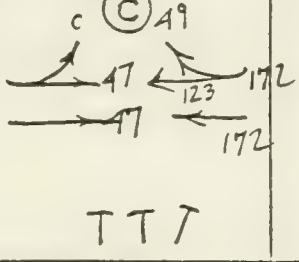
INTERSECTION GEOMETRY



Left Turn Che

	Appr 1	Appr 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
				
CLV= 269	CLV= 100	CLV= 172	CLV=	CLV=

Note: Use 17% reduction in 3ϕ criteria for pedestrians

Σ CLV 541
V/C .46
LOS A

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 (1180)	1375

(#20)

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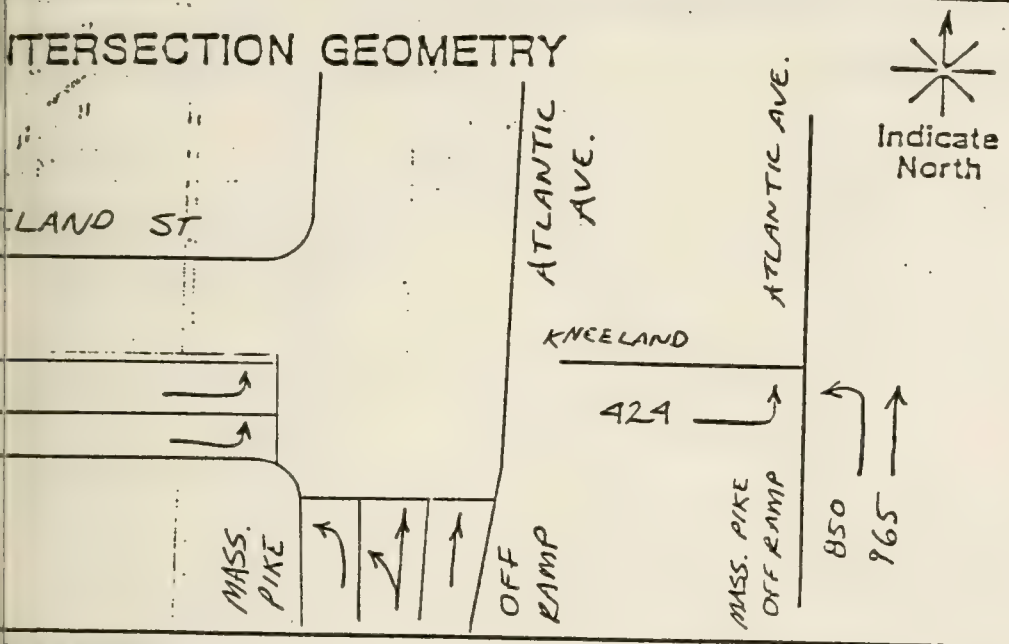
INTERSECTION KNEELAND / ATLANTIC / MASS. PIKE RA
ALT. EXISTING YEAR 1986 PERIOD AM
CALCULATED BY RAR DATE 5-29-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
605 ↑ 245 ↑ 360 ↓ 605 ↑	212 ↑ 212 ↑ T T T			
CLV= 605	CLV= 212	CLV=	CLV=	CLV=

NO REDUCTION DUE TO PEDESTRIANS

Σ CLV 817
V/C .54
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

(#20)

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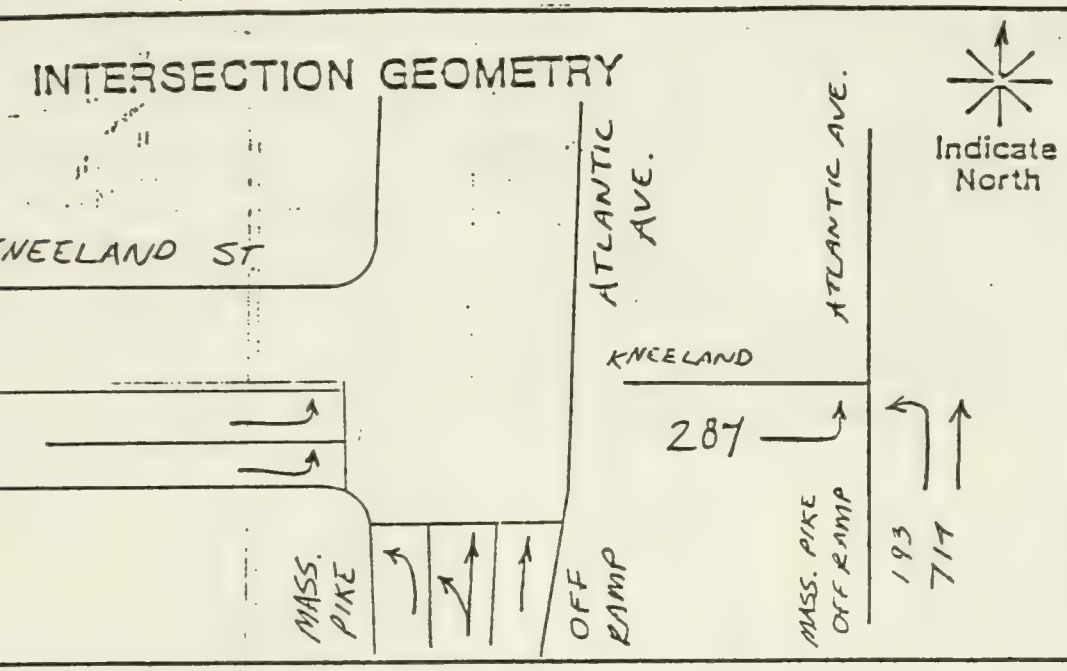
INTERSECTION KNEELAND / ATLANTIC / MASS. PIKE
ALT. EXISTING YEAR 1986 PERIOD PM
CALCULATED BY RAR DATE 5-29-86 SHEET 2 C
CHECKED BY _____ DATE _____ JOB NO. 14

INTERSECTION GEOMETRY



Left Turn Che

	Accre 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
193 ↑ 351 ↑ 351 ↑ T T	144 ↑ 193 ↑ T T T			
CLV= 357	CLV= 144	CLV=	CLV=	CLV=

NO REDUCTION DUE TO PEDESTRIANS

Σ CLV 501
V/C .33
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

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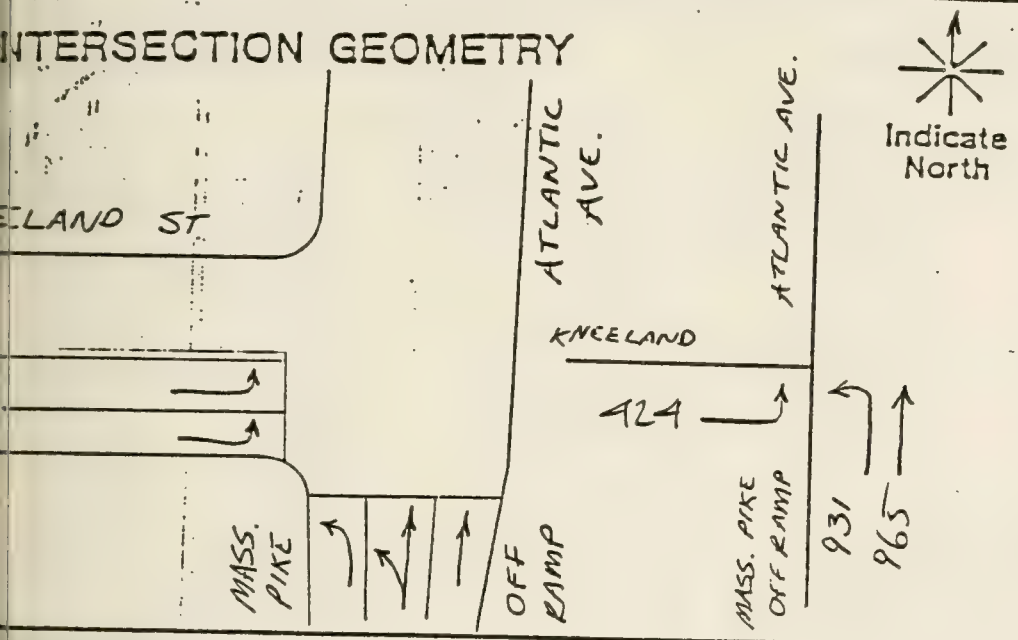
INTERSECTION KNEELAND / ATLANTIC / MASS. PIKE RA
ALT. NO BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-29-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
632 ← 299 ↑ 333 ↑ 632 ↑ 632	212 ↑ 212 ↑ T T T			
CLV= 632	CLV= 212	CLV=	CLV=	CLV=

NO REDUCTION DUE TO PEDESTRIANS

Σ CLV .844
V/C .56
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

VI-A (#20)

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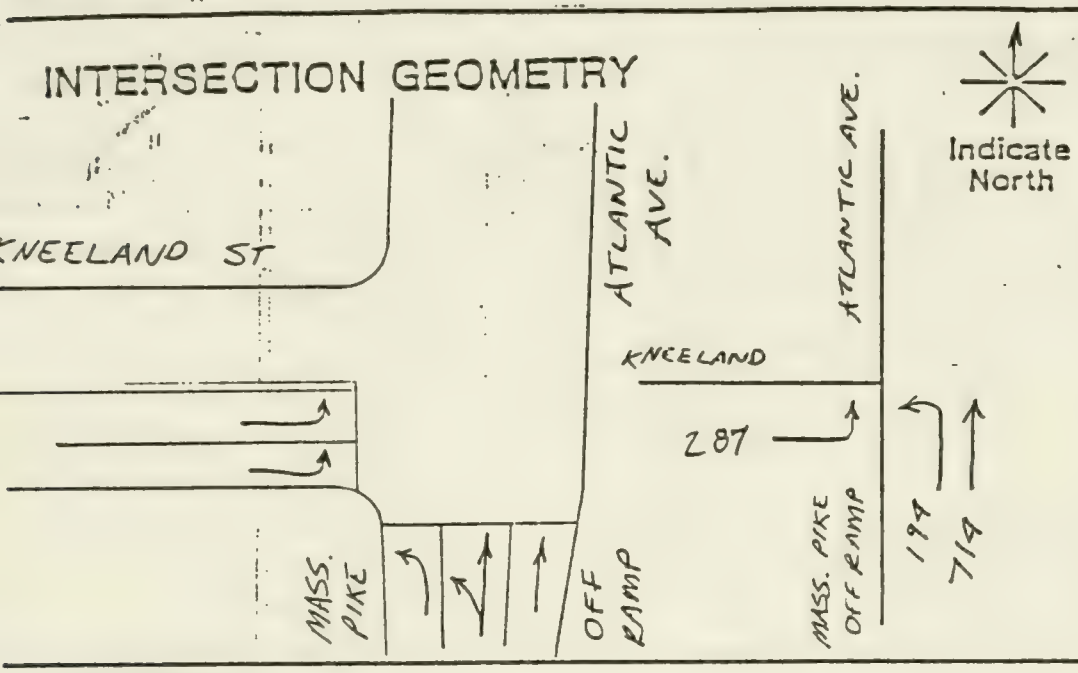
INTERSECTION KNEELAND / ATLANTIC / MASS. PIKE
ALT. NO. BUILD YEAR 1989 PERIOD P.M.
CALCULATED BY RAR DATE 5-29-86 SHEET 4
CHECKED BY _____ DATE _____ JOB NO. 14

INTERSECTION GEOMETRY



Left Turn Che

	Acc 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
194 ↰ 357 ↑ 357 ↑	144 ↑ 143 ↑ T T T			
CLV= 357	CLV= 144	CLV=	CLV=	CLV=

NO REDUCTION DUE TO PEDESTRIANS

Σ CLV 501
V/C .33
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

(#20)

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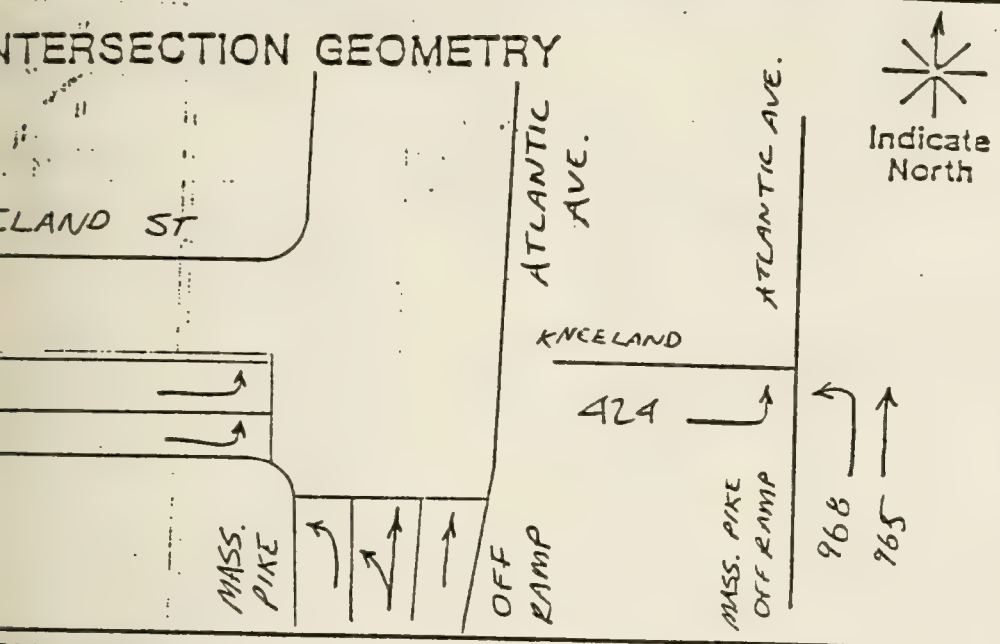
INTERSECTION KNEELAND/ATLANTIC/MASS. PIKE RAM
ALT. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-29-86 SHEET 5 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
44 329 320 645	212 212			
649	T T T			
CLV= 645	CLV= 212	CLV=	CLV=	CLV=

NO REDUCTION DUE TO PEDESTRIANS

Σ CLV 857
V/C .57
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

(#20)

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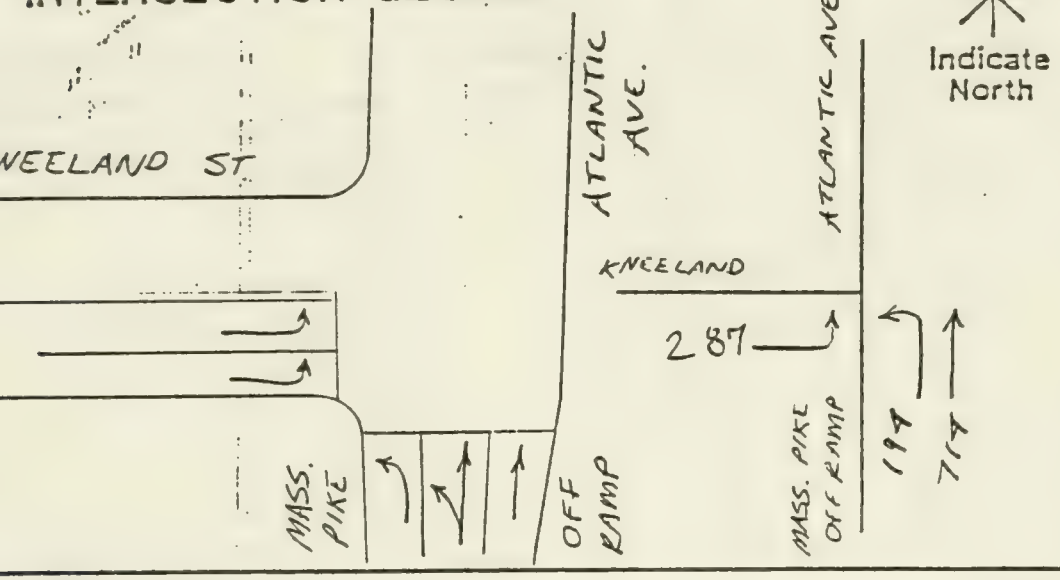
INTERSECTION KNEELAND/ATLANTIC/MASS. PIKE
ALT. BUILD YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5-29-86 SHEET 6 O.
CHECKED BY _____ DATE _____ JOB NO. 148

INTERSECTION GEOMETRY



Left Turn Chec

	Approa 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
194 ↑ 357 ↓ 357 ↑	144 ↑ 143 ↑			
CLV= 357	CLV= 149	CLV=	CLV=	CLV=

NO REDUCTION DUE TO PEDESTRIANS

Σ CLV 501
V/C .33
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

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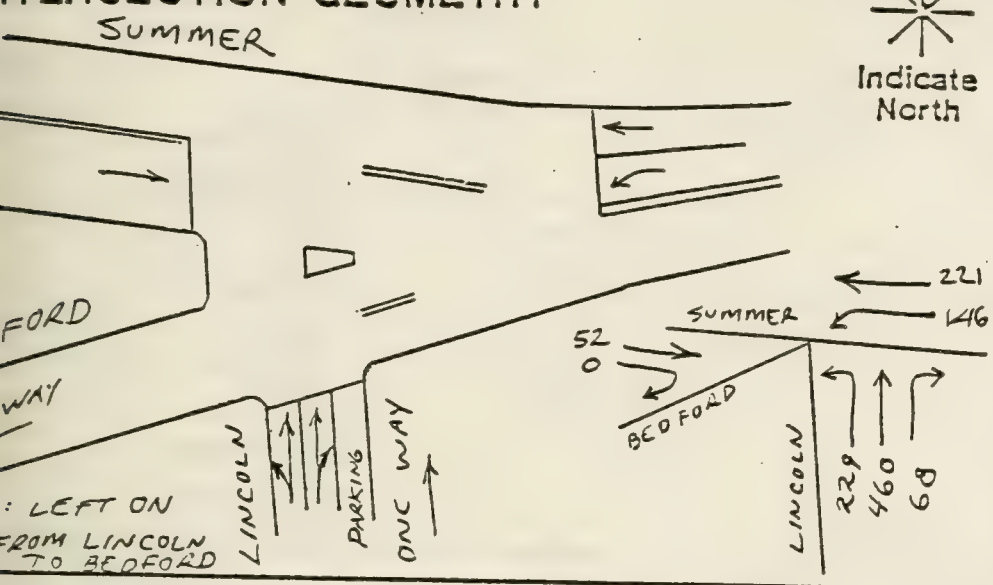
INTERSECTION SUMMER / LINCOLN / BEDFORD
ALT. EXISTING YEAR 1986 PERIOD AM
CALCULATED BY RAR DATE 6-3-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

A	B	C	D	E
52, 221, 146		229, 149, 311, 68, 318, 379		PHASE A = 22 SEC / 100 SEC CYCLE 36 cycles / hour
	ALL VEHICLES PREVIOUSLY CLEARED IN PHASE A			assume 3 SEC START UP + 2 SEC/VEH = 19 SEC OR 9.5 VEH/CYCL 36 CYCLES/HR = 342 VEH
CLV= 221	CLV= 0	CLV= 379	CLV=	CLV=

assume 30% reduction in 2Ø criteria for pedestrians

Σ CLV 600
V/C .57
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 / 1050	1425	1375

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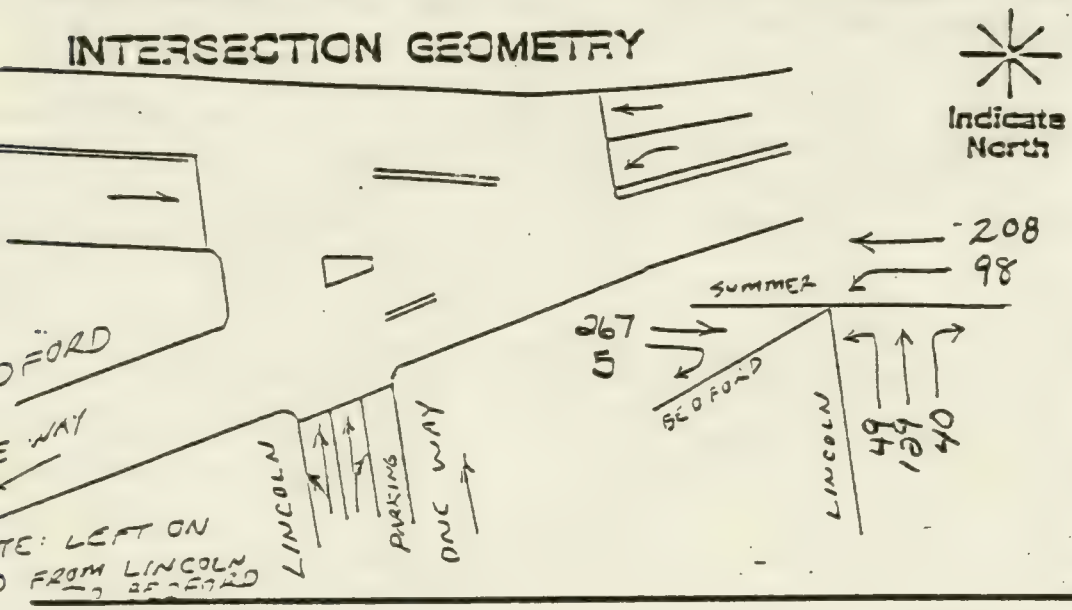
INTERSECTION Summer / Lincoln / Bedford
ALT. Existing YEAR 1996 PERIOD PM
CALCULATED BY: RAR DATE 10-2-86 SHEET 2 OF
CHECKED BY DATE JOB NO. 14289
Rev. 10/14/86

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	Approach 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g ...)?		

PHASING

(A)	(B)	(C)	(D)	(E)
272 267 208 98 TT	TT	49 60 69 40		PHASE A = 30 SEC / 100. 36 Cycles / HR
272 + 98 = 370	ALL VEHICLES PREVIOUSLY CLEARED IN PHASE A	109 109		Assume 3 SE START up + 2 E = 27 SEC OR 13. 36 CYCLES / HR =
CT= 370	CT= 0	CT= 109	CT=	CT=

Assume 30% reduction in 2s criteria for pedestrian

Σ CLV 479
V/C .46
LOS A

CRITERIA (vph)		1 2 E	3 E	4 E
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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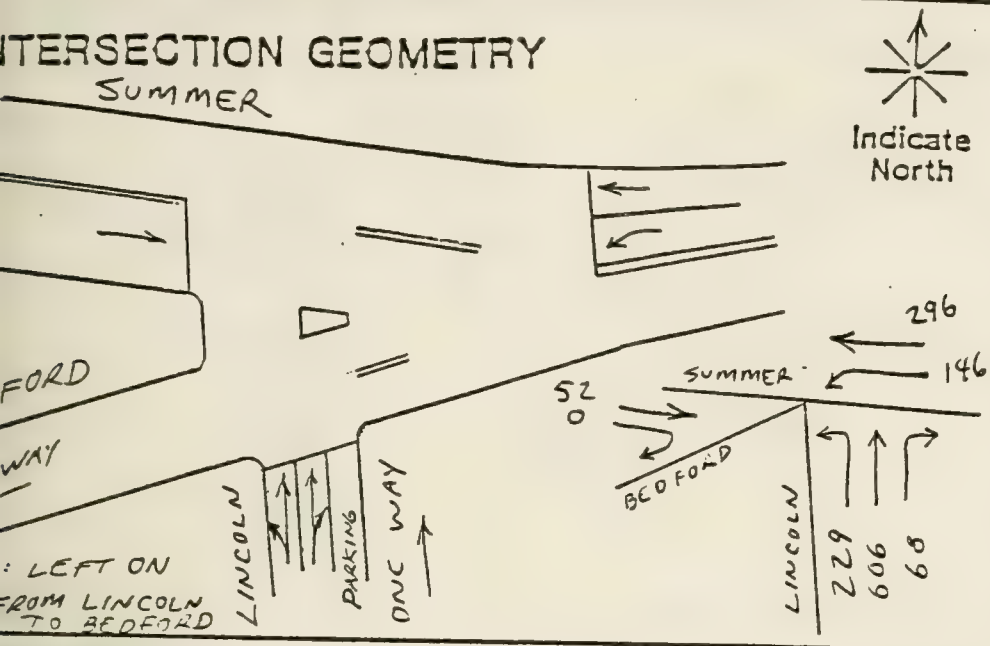
INTERSECTION SUMMER / LINCOLN / BEDFORD
ALT. NO. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 6-3-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

(A)	(B)	(C)	(D)	(E)
52 → 296, ← 146		229 ← 222 ↑ 384 ↑ 68 →		PHASE A = 22 SEC / 100 SEC CYCLE
	ALL VEHICLES PREVIOUSLY CLEARED IN PHASE A			36 cycles / hour
				assume 3 SEC START UP + 2 SEC/VEH = 19 SEC OR 9.5 VEH/CYC.
				36 CYCLES/HR = 342 VEH
CLV= 296	CLV= 0	CLV= 452	CLV=	CLV=

Assume 30% reduction in 2 ϕ criteria for pedestrians

Σ CLV 748
V/C .71
LOS C

CRITERIA (vph)		2 ϕ	3 ϕ	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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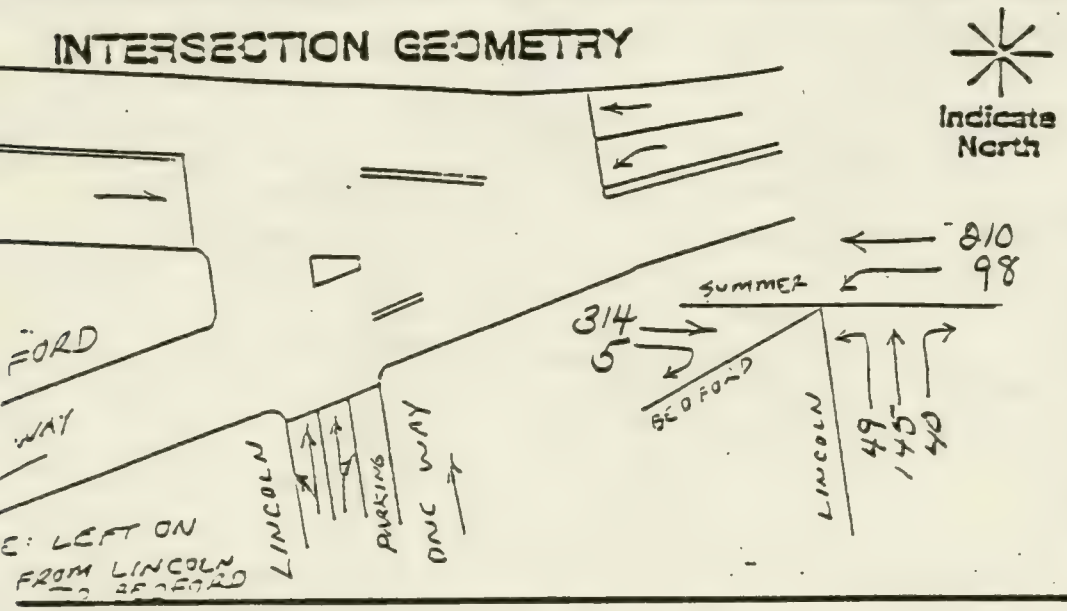
CALCULATED BY RAR DATE 10-3-86 SHEET 4 OF
CHECKED BY _____ DATE _____ JOB NO 1489
Rev. 10/14/86

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	Approach 2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
314, 319, 810, 5, 98 — TT	TT	49, 68, 77, 40 — 117 117		PHASE A = 30 SEC / 100 — 36 Cycles / HR
319 + 98 = 417	ALL VEHICLES PREVIOUSLY CLEARED IN PHASE A			Assume 3 SEC START UP + 2 S. = 37 SEC OR 1.5 — 36 CYCLES / HR =
CV = 417	CV = 0	CV = 117	CV =	CV =

Assume 30% reduction in 2s criteria for pedestrians

Σ CLV 434
V/C .51
LOS A

CRITERIA (vph)		1 2 3	3 3	4 3
LOS	A	900	858	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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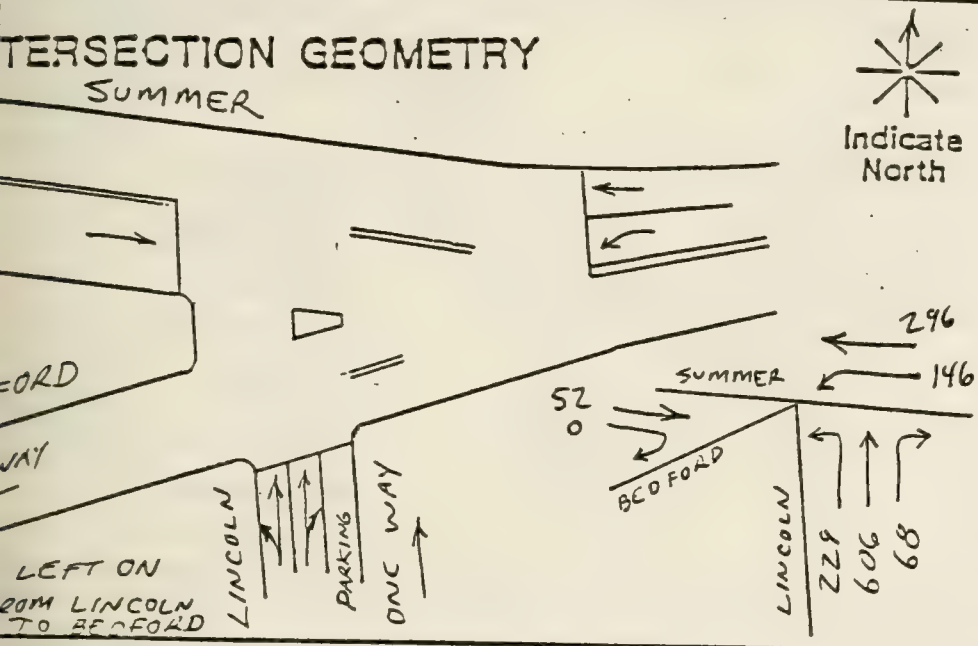
INTERSECTION SUMMER / LINCOLN / BEDFORD
ALT. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 6-3-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > 0)?				

HASING

(A)	(B)	(C)	(D)	(E)
52 296 146		229 222 384 68 451 452		PHASE A = 22 SEC / 100 SEC CYCLE 36 cycles/hour
	ALL VEHICLES PREVIOUSLY CLEARED IN PHASE A			assume 3 SEC START UP + 2 SEC/VEH = 19 SEC OR 9.5 VEH/CYCLE 36 CYCLES/HR = 342 VEH
CLV= 296	CLV= 0	CLV= 452	CLV=	CLV=

assume 30% reduction in 2Ø criteria for pedestrians

Σ CLV 748
V/C .71
LOS C

CRITERIA (vph)		2Ø	3Ø	4Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

(# 11)

Vanasse / Hangen Engineering, Inc.
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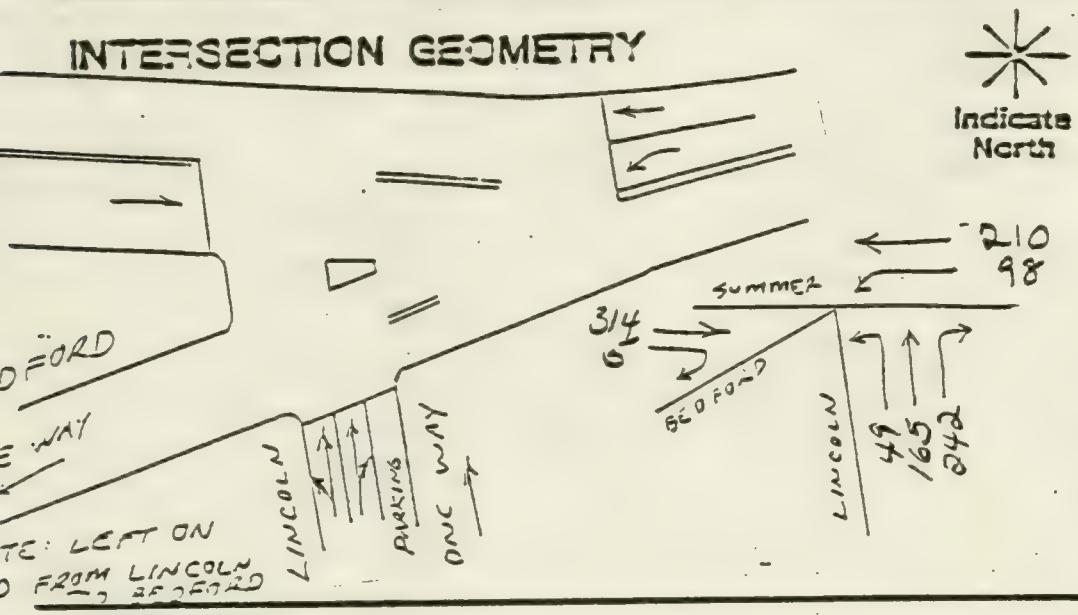
184 High Street, Boston, Massachusetts 02110
617 / 482-7870

INTERSECTION Summer / Lincoln / Bedfo
ALT. Build YEAR 1986 PERIOD PM
CALCULATED BY RAR DATE 6-3-86 SHEET 6 O
CHECKED BY DATE JOB NO. 1148
Rev 10/14/86

INTERSECTION GEOMETRY



Left Turn Chec

	Approa 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
314 319 210 6 98 TT	TT	49 165 242		PHASE A = 30 SEC / 100 36 Cycles / HR
319 + 98 = 417	ALL VEHICLES PREVIOUSLY CLEARED IN PHASE A	2/4 2/2		Assume 3 SE START UP + 2 E = 27 SEC OR 13 36 CYCLES / HR =
CV= 417	CV=	CV= 242	CV=	CV=

Assume 30% reduction on 2s criteria in pedestrian

Σ CLV 659
V/C .63
LOS B

CRITERIA (vph)		2 E	3 E	4 E
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

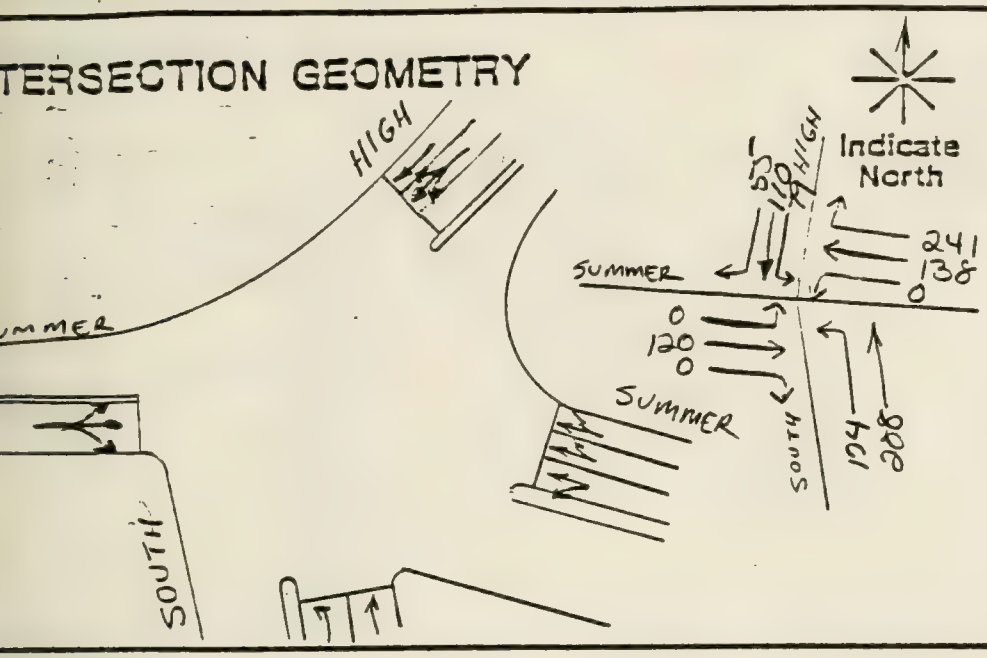
1050

(#10)

sse/Hangen Engineering, Inc.
lting Engineers & Planners
mingham Parkway, Boston, MA 02135
33-7000

INTERSECTION SUMMER / HIGH / SOUTH
ALT. Existing YEAR 1986 PERIOD A.M
CALCULATED BY RAR DATE 5/22/86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489
Rev 10/14/86

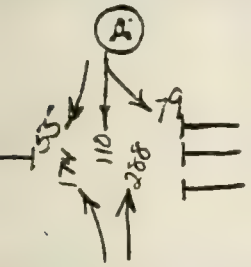
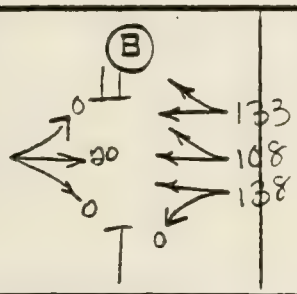
TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

A	B	C	D	E
	 55% 45%			
174 + 110 = 284				
CLV= 284	CLV= 138	CLV=	CLV=	CLV=

Assume 30% reduction in LP criteria for pedestrians

Σ CLV 422
V/C .40
LOS A

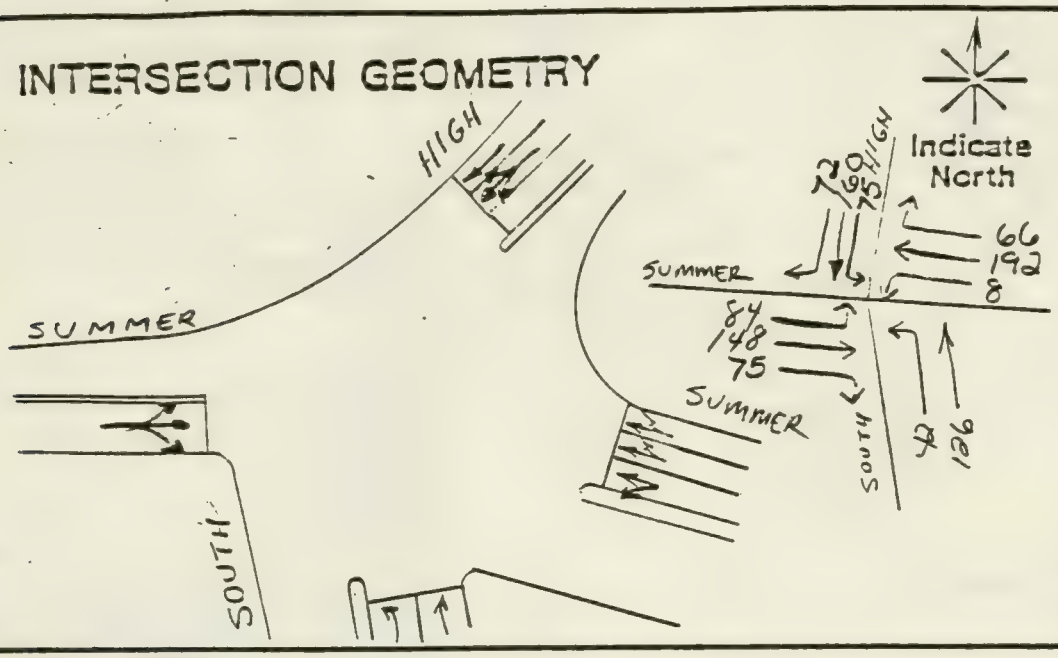
CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500 1050	1425	1375

(#10)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION SUMMER / HIGH / SOUTH
ALT. Existing YEAR 1986 PERIOD PM
CALCULATED BY RAR DATE 5/22/86 SHEET 2 OF
CHECKED BY DATE JOB NO. 1489
Rev 10/14/86

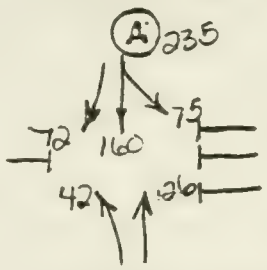
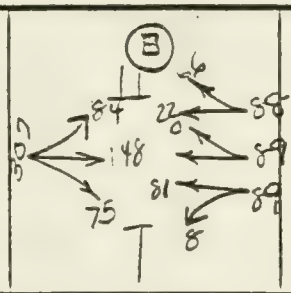
INTERSECTION GEOMETRY



Left Turn Check

	Approac 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
				
235 + 42 = 277	223 + 8 = 231 ∩ 307			
CLV= 277	CLV= 307	CLV=	CLV=	CLV=

assume 30% reduction in LP criteria for pedestrians

Σ CLV 584
V/C .56
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

(#10)

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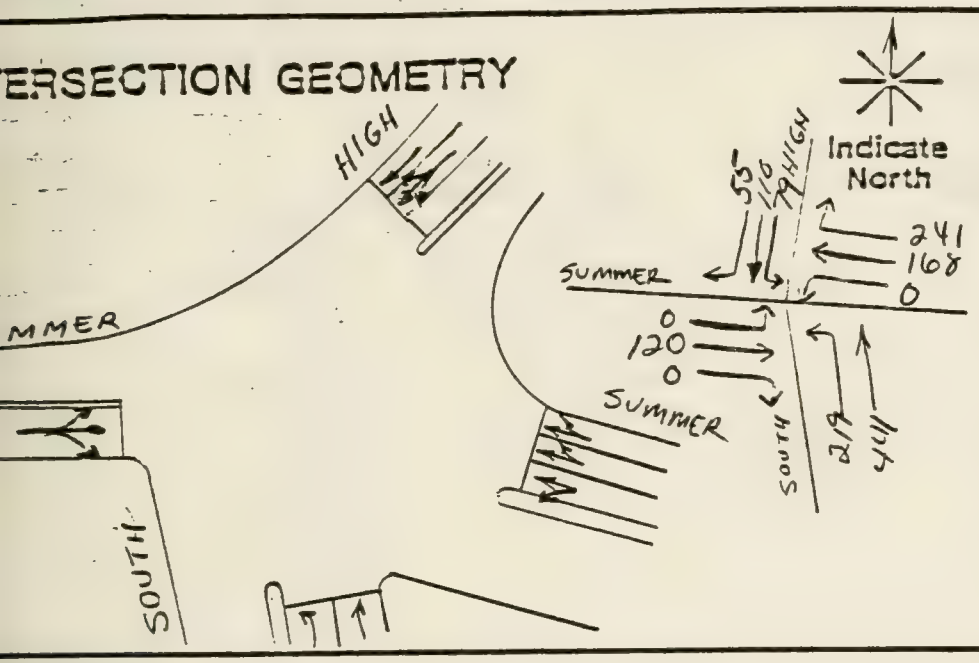
INTERSECTION SUMMER / HIGH / SOUTH
ALT. No Build YEAR 1987 PERIOD PM
CALCULATED BY RAR DATE 5/22/86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489
Rev. 10/14/86

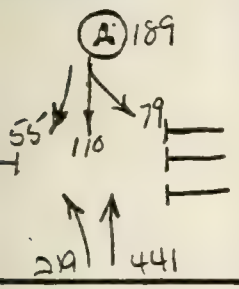
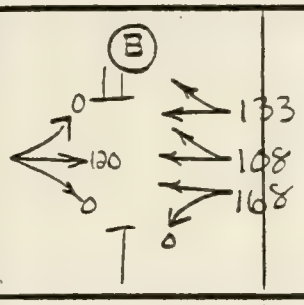
ERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

A	B	C	D	E
				
110 + 219 = 329				
CLV= 329	CLV= 168	CLV=	CLV=	CLV=

assume 30% reduction in 2Ø criteria for pedestrians

Σ CLV 497
V/C .47
LOS A

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

VHB (#10)

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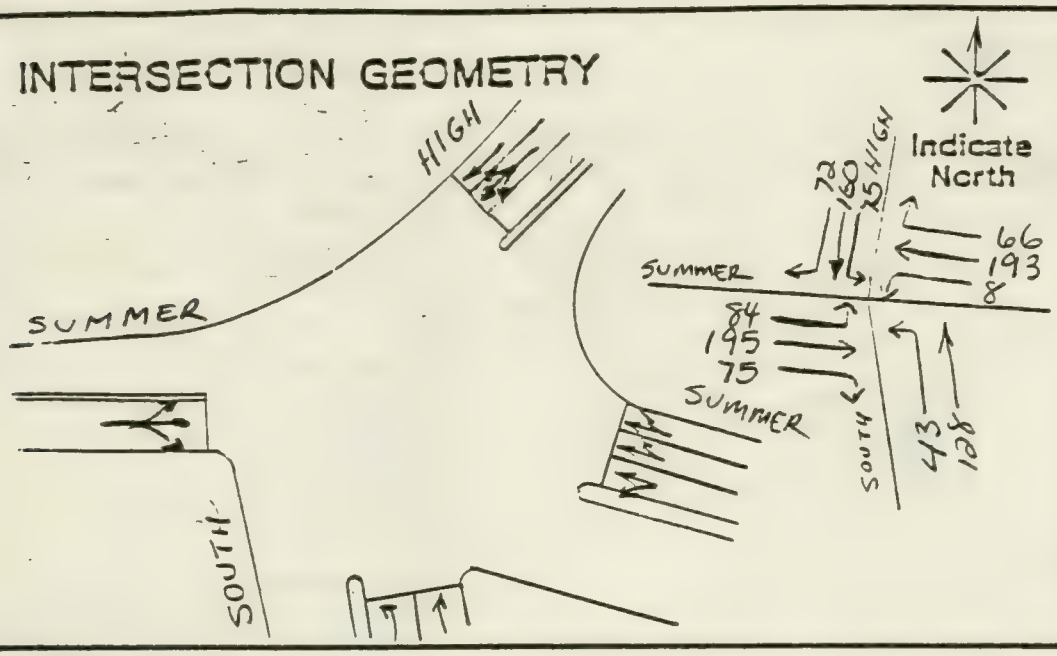
INTERSECTION SUMMER / HIGH / SOUTH
ALT. No Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5/22/86 SHEET 4 OF
CHECKED BY _____ DATE _____ JOB NO. 1489
Rev 10/14/86

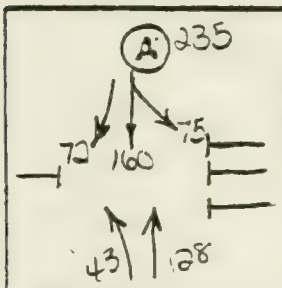
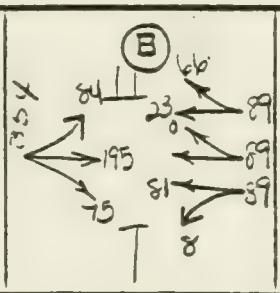
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
				
235 + 43 = 278	354 + 8 = 362			
CLV= 278	CLV= 362	CLV=	CLV=	CLV=

Assume 30% reduction in LT criteria for pedestrians

Σ CLV 640
V/C .61
LOS B

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

(#10)

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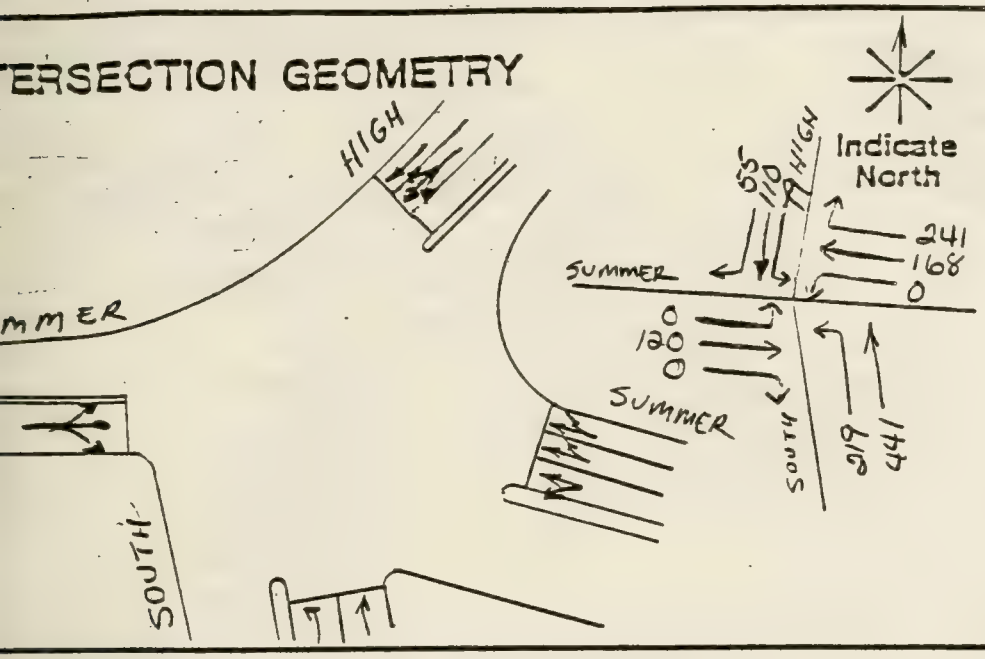
ing Engineers & Planners
ningham Parkway, Boston, MA 02135
3-7000

INTERSECTION SUMMER / HIGH / SOUTH
ALT. Build YEAR 1987 PERIOD AM
CALCULATED BY RAR DATE 5/22/86 SHEET 5 OF 6
CHECKED BY ____ DATE ____ JOB NO. 1489
Rev. 10/14/86

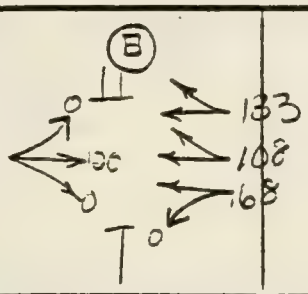
TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

(A)	(B)	(C)	(D)	(E)
				
110 + 219 = 329				
CLV= 329	CLV= 168	CLV=	CLV=	CLV=

Assume 30% reduction in LP criteria for pedestrians

Σ CLV 497
V/C .47
LOS A

CRITERIA (vph)		(2 Ø)	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

VH (#10)

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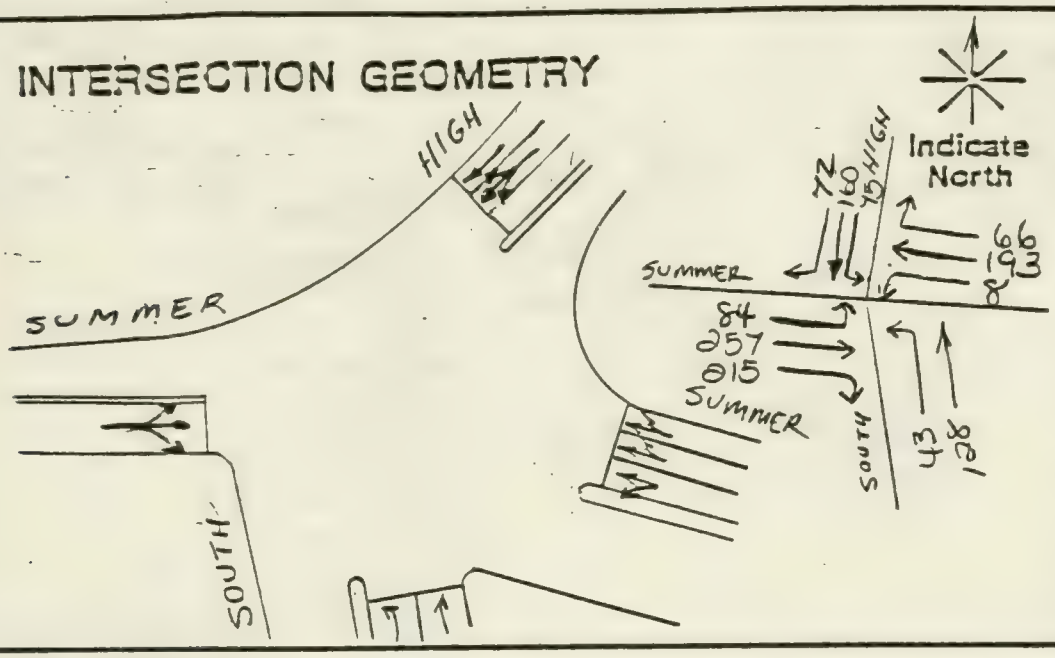
617/783-7000

INTERSECTION SUMMER / HIGH / SOUTH
ALT. Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5/20/86 SHEET 6 OF
CHECKED BY DATE JOB NO. 1489
Rev 10/14/86

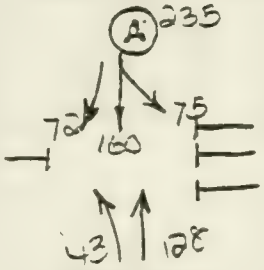
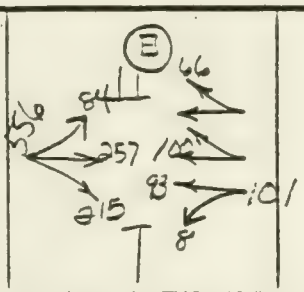
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
				
43 + 235 = 278	556 + 8 = 564			
CLV = 278	CLV = 564	CLV =	CLV =	CLV =

Assume 30% reduction in LP criteria for pedestrians

Σ CLV 842
V/C .80
LOS C

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1050

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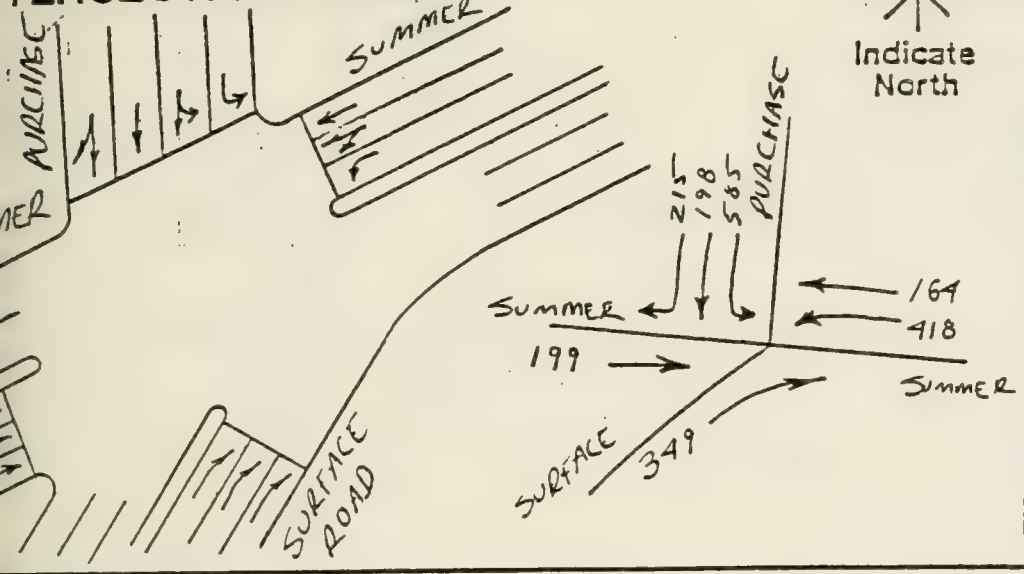
INTERSECTION SURFACE ROAD / SUMMER / PURCHAS
ALT. EXISTING YEAR 1986 PERIOD A.M.
CALCULATED BY RAR DATE 5-22-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

TERSECTION GEOMETRY

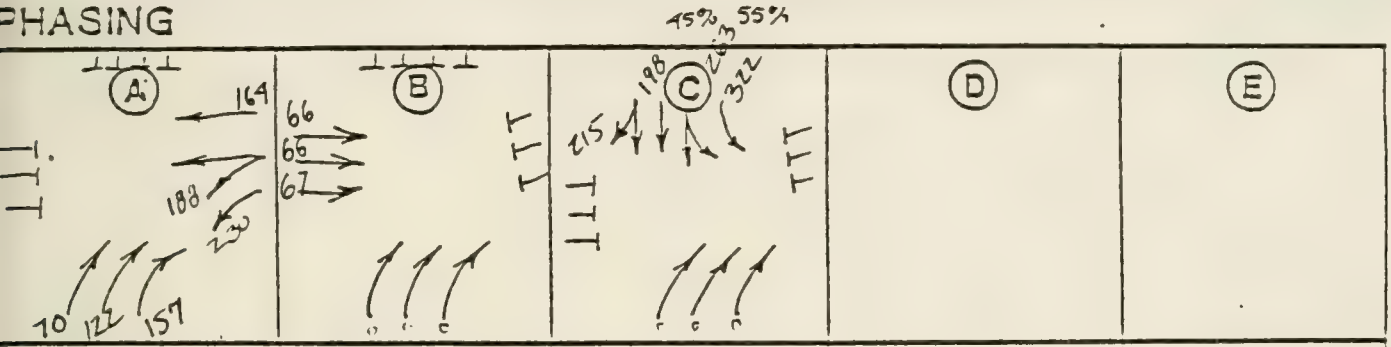


Indicate North

Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING



20% 35% 45%

45%
55%

use CLV min. value of 100

CLV= 230	CLV= 100	CLV= 322	CLV=	CLV=

assume 30% reduction in 3Ø criteria for pedestrians

Σ CLV 652
V/C .65
LOS B

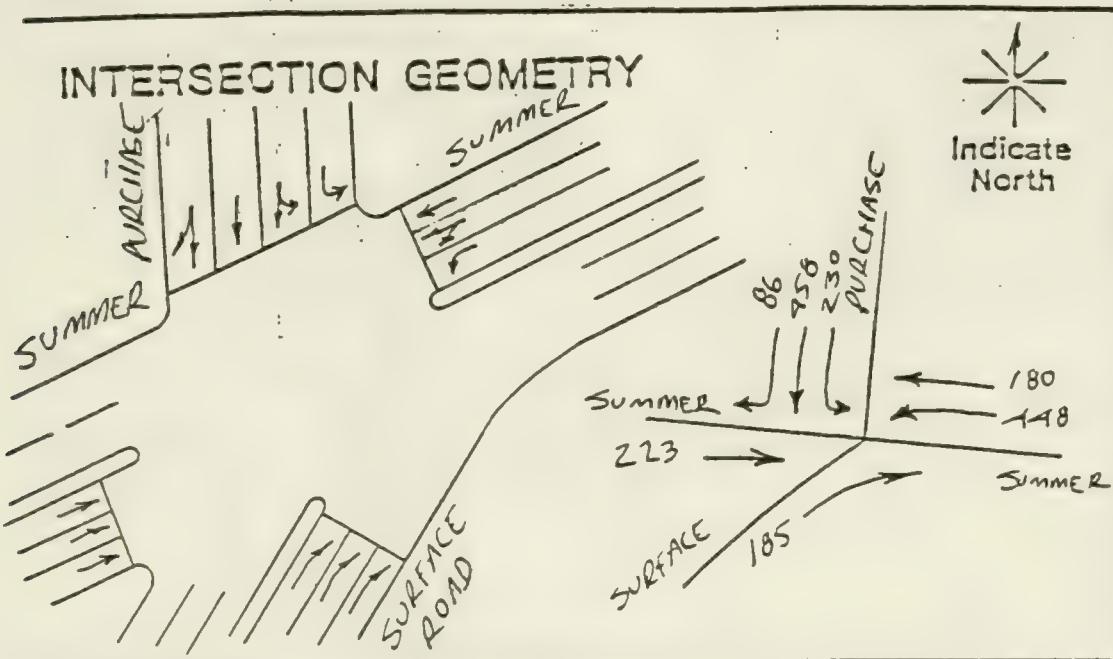
CRITERIA (vph)		2 Ø	(3 Ø)		4 Ø
LOS	A	900	855		825
	B	1050	1000		965
	C	1200	1140		1100
	D	1350	1275		1225
	E	1500	1425	998	1375

VC (#9)

Vanasse/Hangen Engineering, Inc.
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135
617/783-7000

INTERSECTION SURFACE ROAD / SUMMER / PC
ALT. EXISTING YEAR 1986 PERIOD P.
CALCULATED BY RAR DATE 5-28-86 SHEET 2
CHECKED BY _____ DATE _____ JOB NO. 14

INTERSECTION GEOMETRY

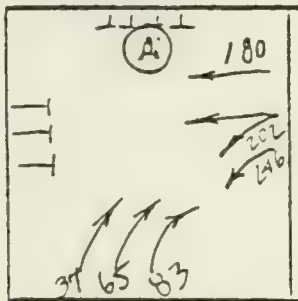
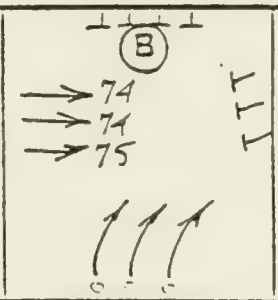
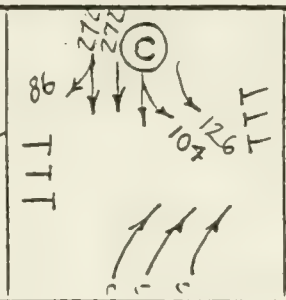


Left Turn Che

	Accm 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

45% 55%

A	B	C	D	E
				
20% 35% 45%- 45% 55%-	Use min. CLV value of 100			
CLV= 246	CLV= 100	CLV= 272	CLV=	CLV=

Assume 30% reduction in 3Ø criteria for pedestrians

Σ CLV 618
V/C .62
LOS B

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 996	1375

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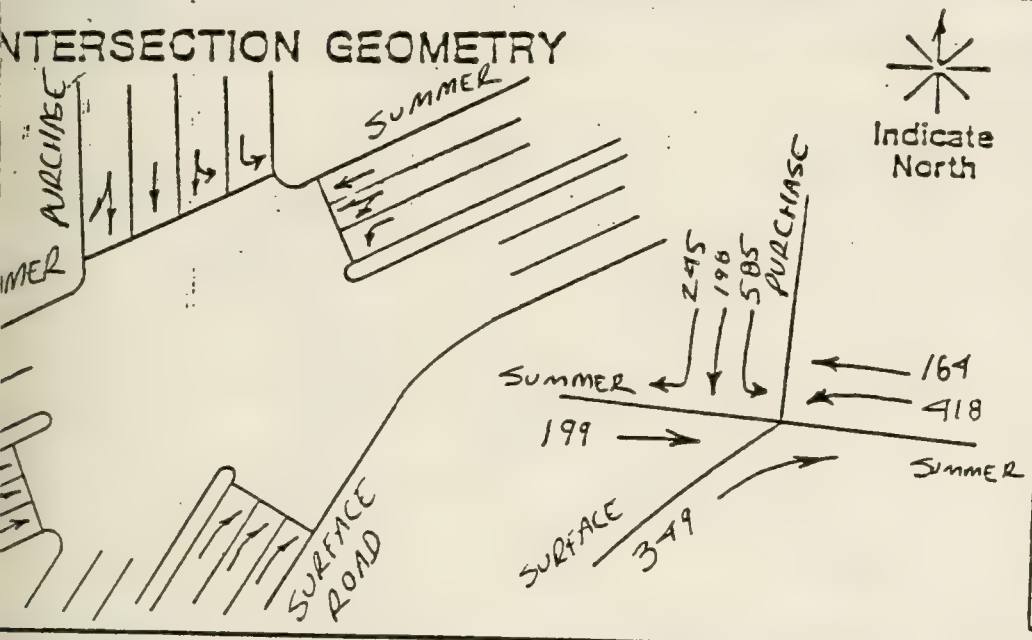
INTERSECTION SURFACE ROAD / SUMMER / PURCHA
ALT. NO BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-22-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1989

INTERSECTION GEOMETRY

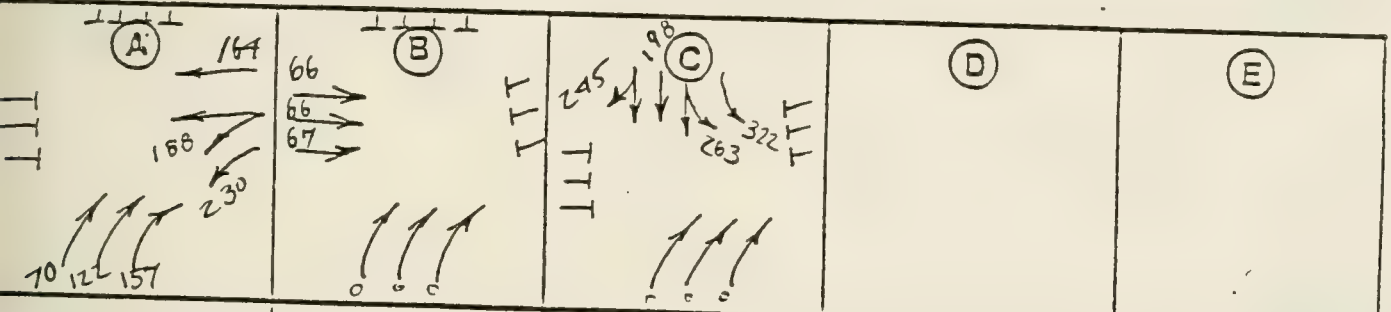


Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

45% 55%



20% 35% 45%
45%
55%

use min. CLV value of 100

CLV= 230	CLV= 100	CLV= 322	CLV=	CLV=

Assume 30% reduction in 3Ø criteria for pedestrians

Σ CLV 652
V/C .65
LOS B

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 996	1375

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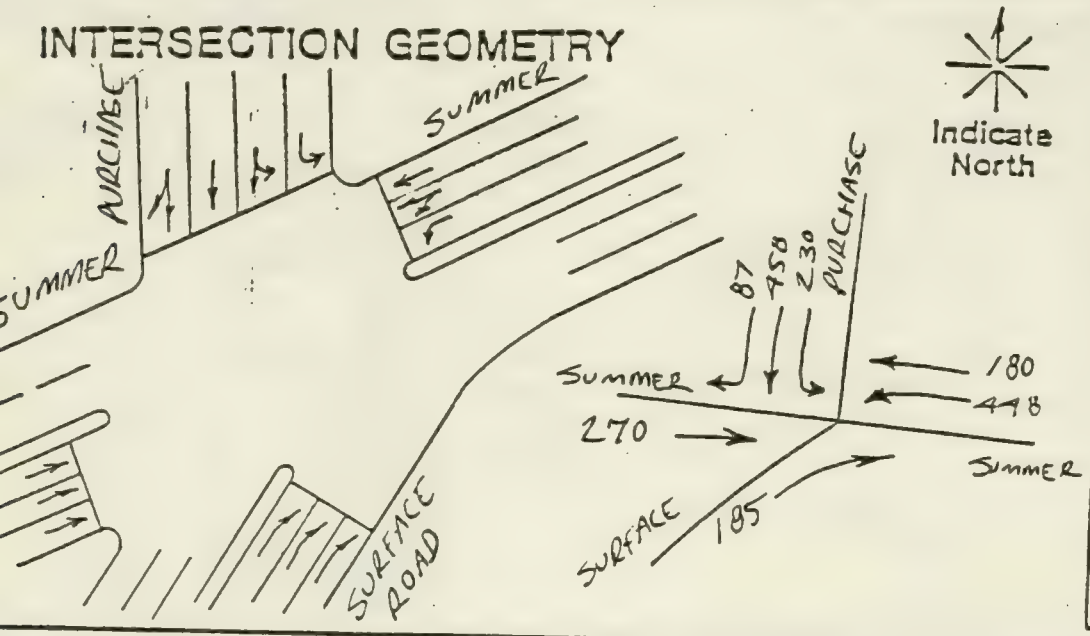
INTERSECTION SURFACE ROAD / SUMMER / PUR
ALT. NO BUILD YEAR 1989 PERIOD P.M.
CALCULATED BY RAR DATE 5-22-86 SHEET 1 O
CHECKED BY _____ DATE _____ JOB NO. 196

INTERSECTION GEOMETRY

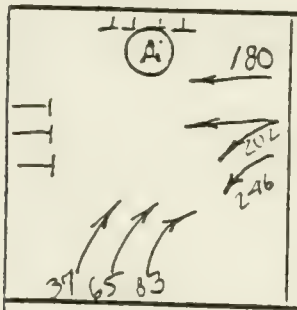
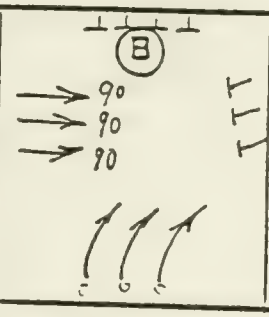
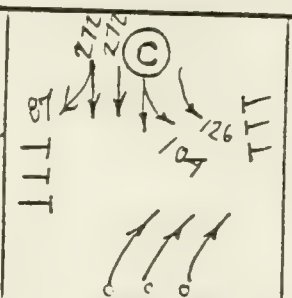


Left Turn Chec

	Approa 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

15% 55%

A	B	C	D	E
				
20% 35% 45% 15% 55%	see CLV min value of 100			
CLV= 246	CLV= 100	CLV= 272	CLV=	CLV=

Assume 30% reduction in 3Ø criteria for pedestrians

Σ CLV 618
V/C .62
LOS B

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 996	1375

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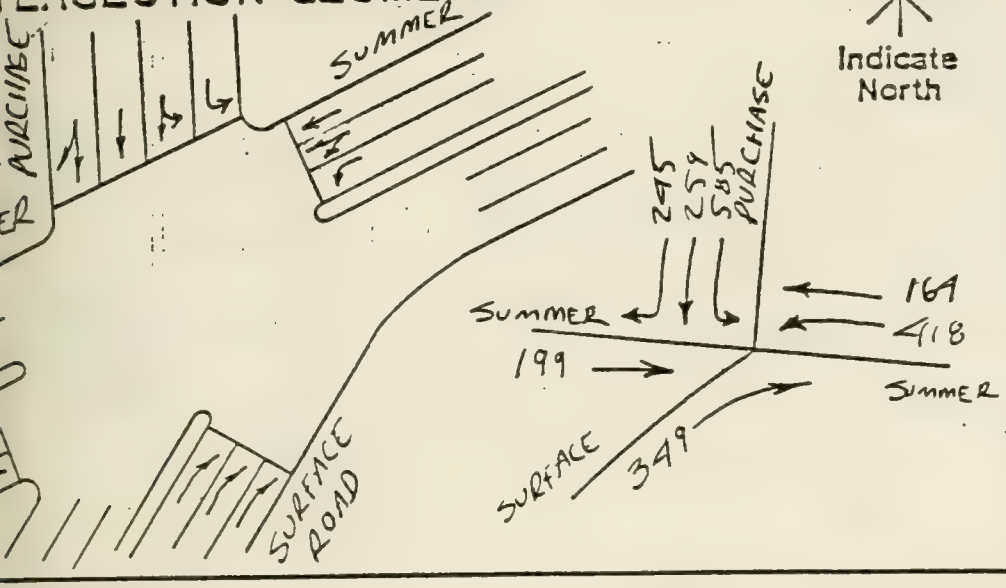
INTERSECTION SURFACE ROAD / SUMMER / PURCHASE
ALT. BUILD YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5-22-86 SHEET 5 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1989

TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + c)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

.45 .50

A	B	C	D	E
164, 185, 230, 70, 122, 157	66, 66, 67	245, 259, 7, 263, 322		
.20 .35 .45 .45 .50	use min CLV value of 100			
CLV= 230	CLV= 100	CLV= 322	CLV=	CLV=

Assume 30% reduction in 3Ø criteria for pedestrians

Σ CLV 652
V/C .65
LOS B

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 998	1375

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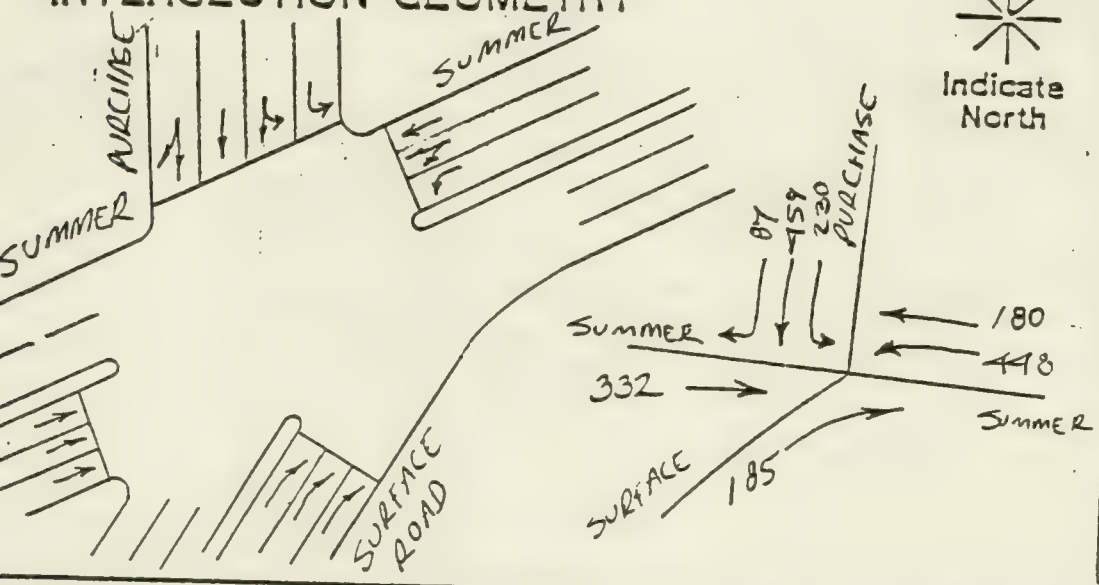
INTERSECTION SURFACE ROAD / SUMMER / PU
ALT. BUILD YEAR 1989 PERIOD P. M
CALCULATED BY RAR DATE 5-22-86 SHEET 6 O
CHECKED BY _____ DATE _____ JOB NO. 19

INTERSECTION GEOMETRY



Left Turn Chec

	Approa 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

.45 .55

A	B	C	D	E
180, 202, 246, 37, 65, 83	110, 111, 111	87, 273, 273, 186, 104, 126		
2 .35 .45 .15 .55				
CLV= 246	CLV= 111	CLV= 273	CLV=	CLV=

Assume 30% reduction in 3Ø criteria for pedestrians

Σ CLV 621
V/C .62
LOS B

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 998	1375

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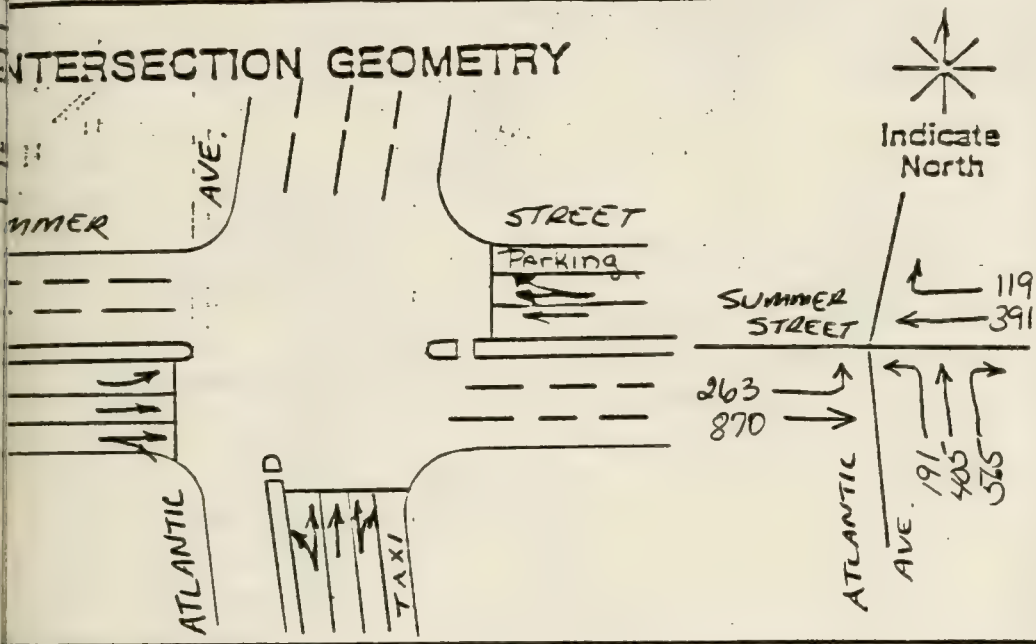
INTERSECTION ATLANTIC AVE. & SUMMER ST.
ALT. Existing YEAR 1986 PERIOD AM
CALCULATED BY RAR DATE 6-11-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

A	B	C	D	E
263, 263, 263, 0	119, 136, 255, 172, 172, 255, 0	191, 107, 0, 565, 298, 298		
CLV= 263	CLV= 255	CLV= 565	CLV=	CLV=

Note: 30% reduction in 3 Ø criteria due to pedestrians

Σ CLV 1083
V/C 1.09
LOS F

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 998	1375

VI-1 (PM)

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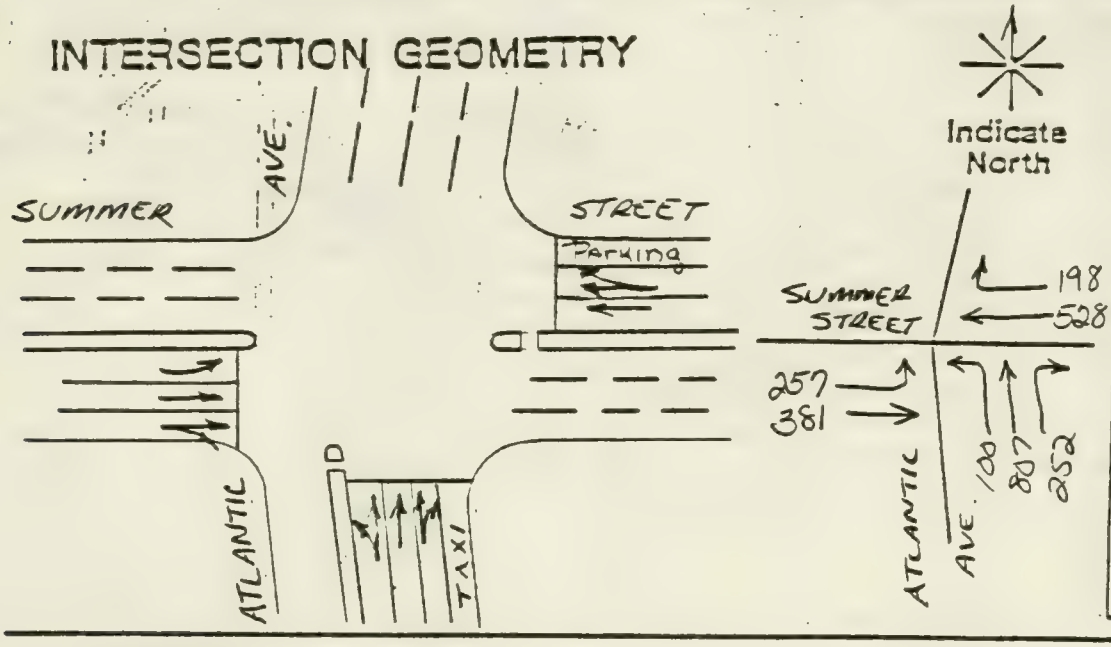
INTERSECTION ATLANTIC AVE. & SUMMER S
ALT. EXISTING YEAR 1986 PERIOD P.M.
CALCULATED BY RAR DATE 6-11-86 SHEET 2 O
CHECKED BY _____ DATE _____ JOB NO. 148

INTERSECTION GEOMETRY



Left Turn Chec

	Accra 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
257 → 191 → 190 → 0 TTT	198 ← 165 ← 363 ← 363; 0 → 0 → 0 TTT	100 → 286 → 134 → 253 TTT; 386 387 384		
CLV= 257	CLV= 363	CLV= 387	CLV=	CLV=

Note: 30% reduction in 3 Ø criteria due to pedestrians

Σ CLV 1007
V/C 1.01
LOS F

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 998	1375

(#8)

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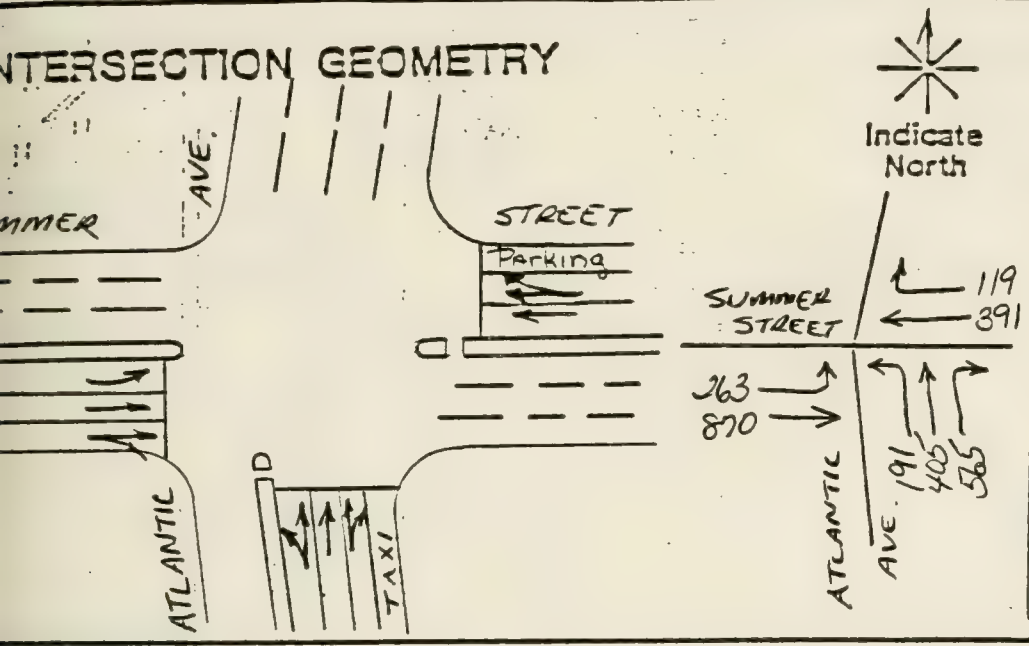
INTERSECTION ATLANTIC AVE. & SUMMER ST.
ALT. No Build YEAR 1989 PERIOD A.M.
CALCULATED BY RAR DATE 6-11-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + c)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

A	B	C	D	E
263 → 263 → 263 → 0 TTT	119 ← 136 ← 255 ← 255; 172 → 172 → 0 TTT	191 → 107 → 0 → 565 TTTT; 298 298		
CLV= 263	CLV= 255	CLV= 565	CLV=	CLV=

Note: 30% reduction in 3 Ø criteria due to pedestrians

Σ CLV 1083
V/C 1.09
LOS F

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 998	1375

VH (#8)

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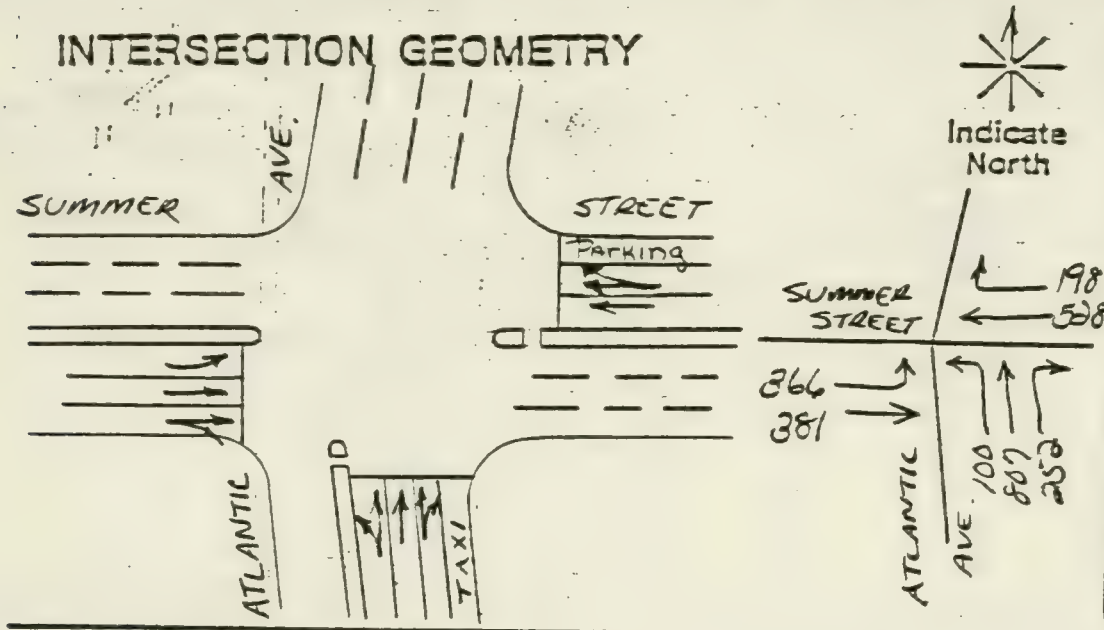
INTERSECTION ATLANTIC AVE. & SUMMER S
ALT. Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 6-11-86 SHEET 6
CHECKED BY _____ DATE _____ JOB NO. 148

INTERSECTION GEOMETRY



Left Turn Che

Accre

	1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. C/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
366 → 191 → 190 ↓ 0 TTT	198 ← 165 ← 363 ← 363 ; 0 ; 0 TTT	286 ↑ 134 ↑ 252 TTT ; 100 ↑ ↑ ↑ ; 386 967 386		
CLV= 366	CLV= 363	CLV= 387	CLV=	CLV=

Note: 30% reduction in 3 Ø criteria due to pedestrians

Σ CLV 1116
V/C 1.12
LOS F

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 998	1375

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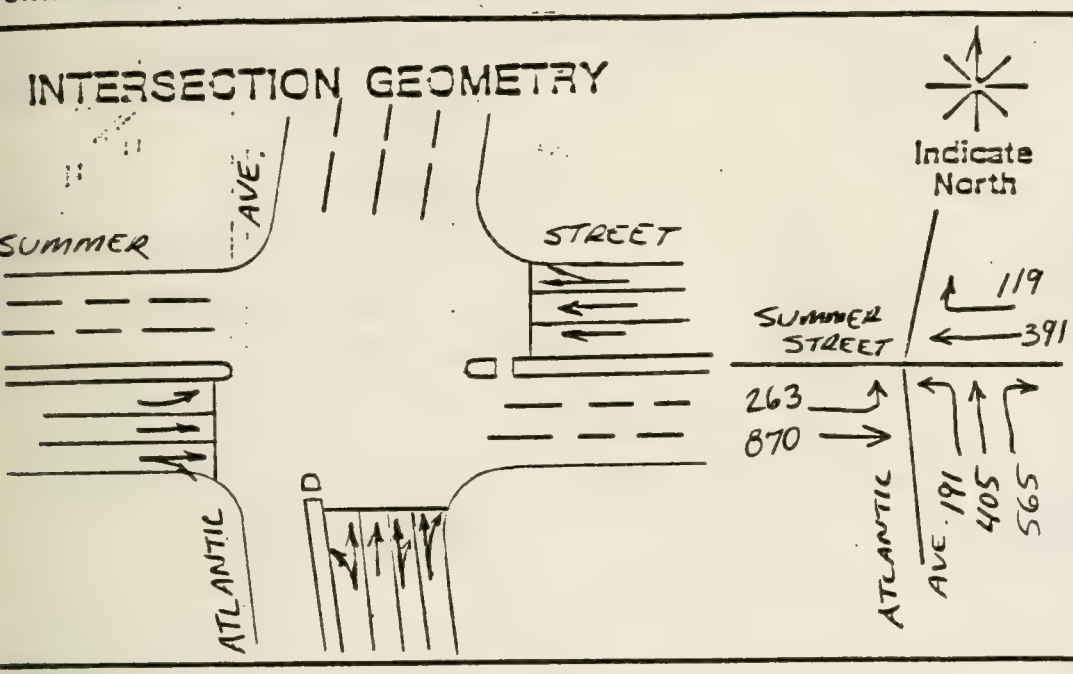
INTERSECTION ATLANTIC AVE. & SUMMER ST.
ALT. MITIGATION YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 12-11-86 SHEET 1 OF 2
CHECKED BY _____ DATE _____ JOB NO. 1489

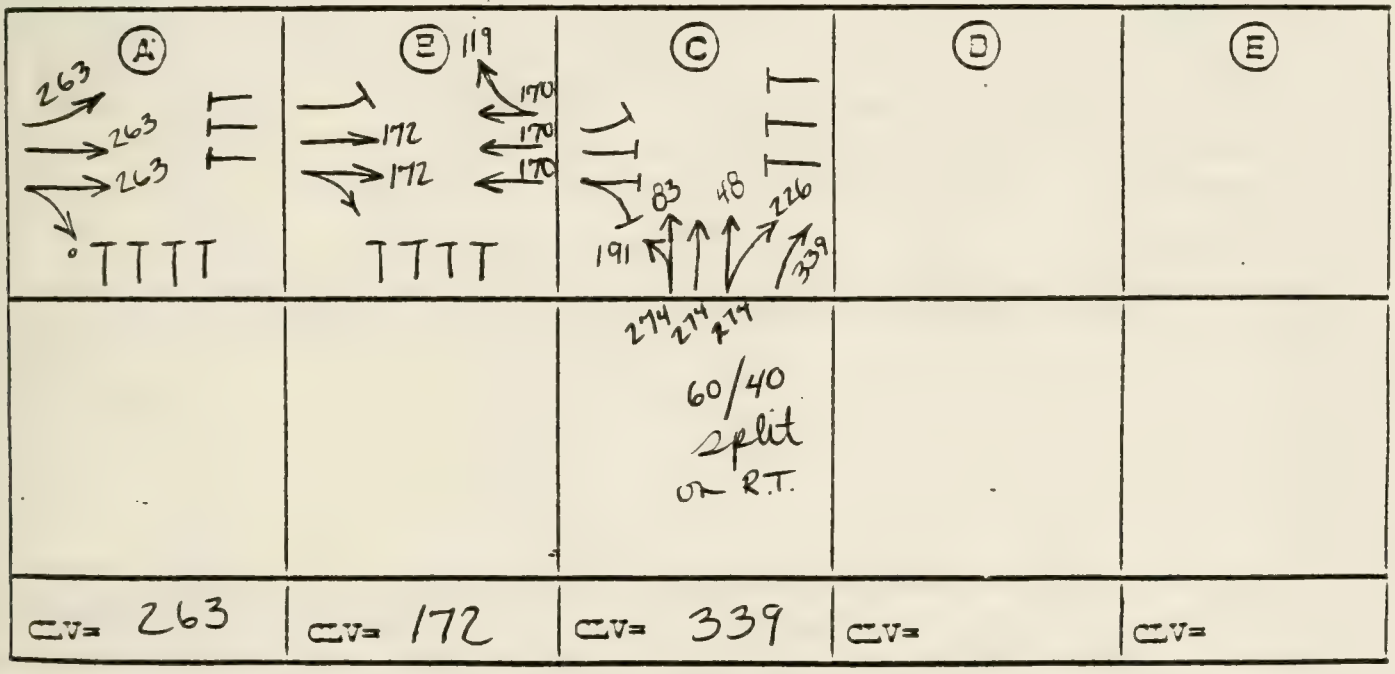
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + e)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING



A	B	C	D	E
CLV= 263	CLV= 172	CLV= 339	CLV=	CLV=

Note: 30% reduction in 3 Ø criteria due to pedestrians

Σ CLV 774
V/C 0.78
LOS C

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 998	1375

(#8)

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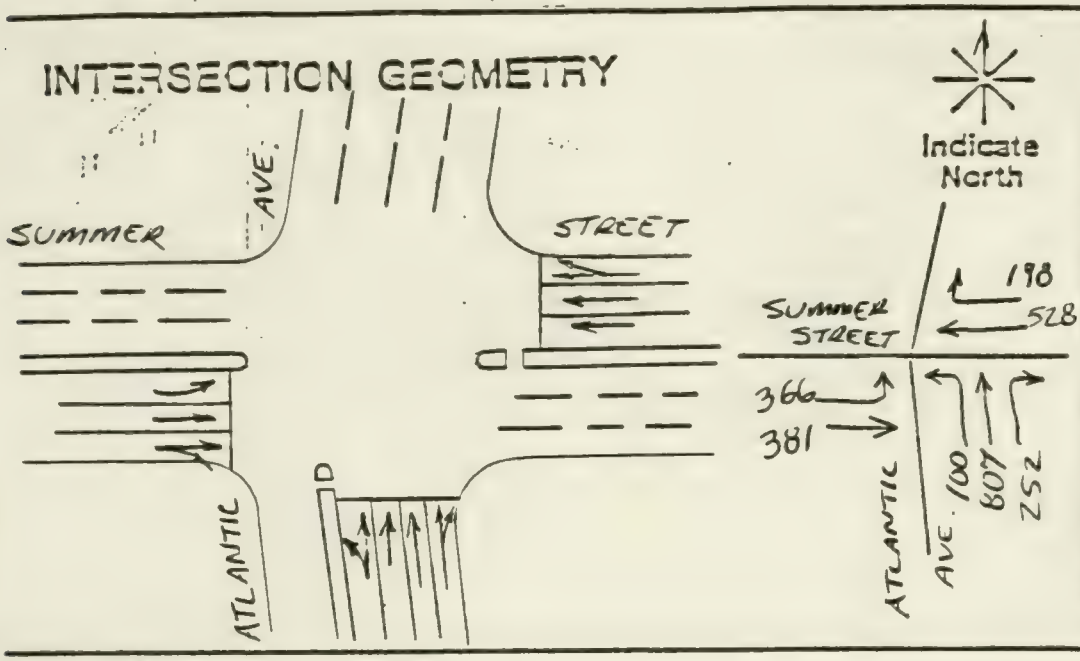
INTERSECTION ATLANTIC AVE. & SUMMER S
ALT. MITIGATION YEAR 1987 PERIOD PM
CALCULATED BY RAR DATE 12-11-86 SHEET 2
CHECKED BY _____ DATE _____ JOB NO. 14

INTERSECTION GEOMETRY



Left Turn Che

	Accr 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + e)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
366, 191, 190	198, 44, 242, 242	100, 202, 52, 302, 302, 30		
CLV= 366	CLV= 242	CLV= 303	CLV=	CLV=

Note: 30% reduction in 3 Ø criteria due to pedestrians

Σ CLV 911
V/C 0.91
LOS E

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 798	1375

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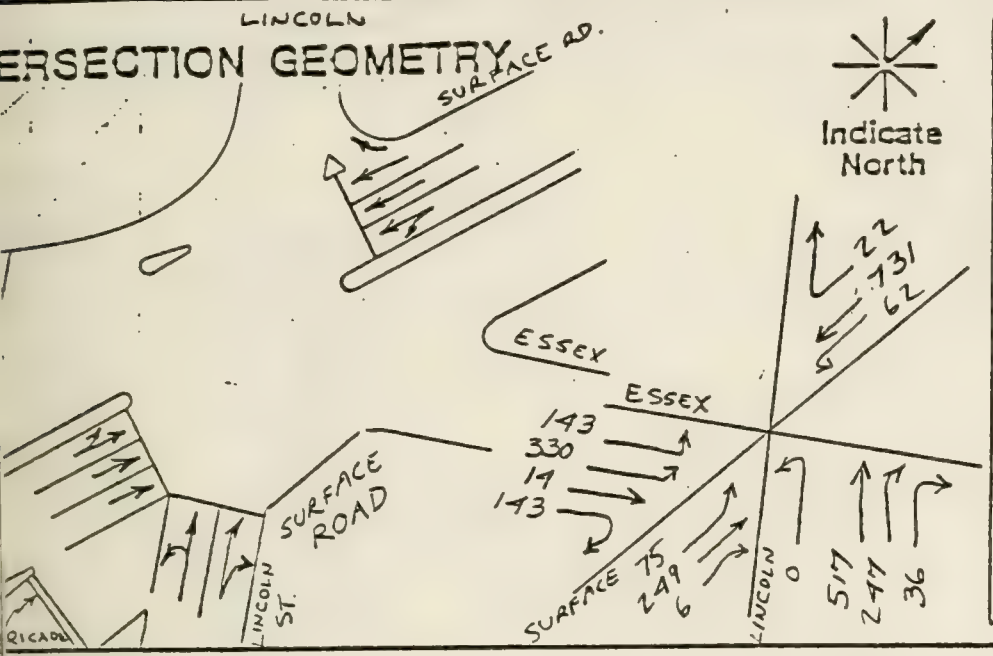
INTERSECTION ESSEX / LINCOLN & SURFACE RD.
ALT. EXISTING YEAR 1986 PERIOD AM
CALCULATED BY RAR DATE 5-27-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

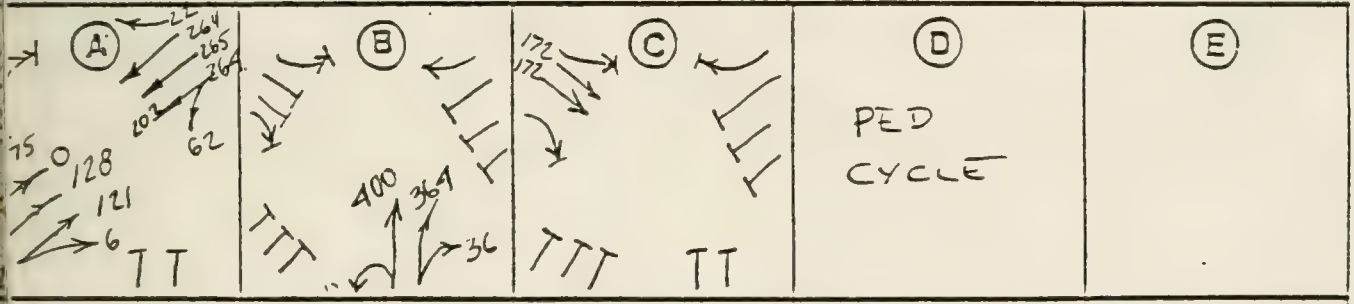
ERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

ASING



5 + 265 = 340

CLV= 340 | CLV= 400 | CLV= 172 | CLV= | CLV=

Note: 20% reduction in 3ϕ criteria for pedestrians

Σ CLV 912
V/C .80
LOS C

CRITERIA (vph)		2 ϕ	(3 ϕ)	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 /1140	1375

(#5)

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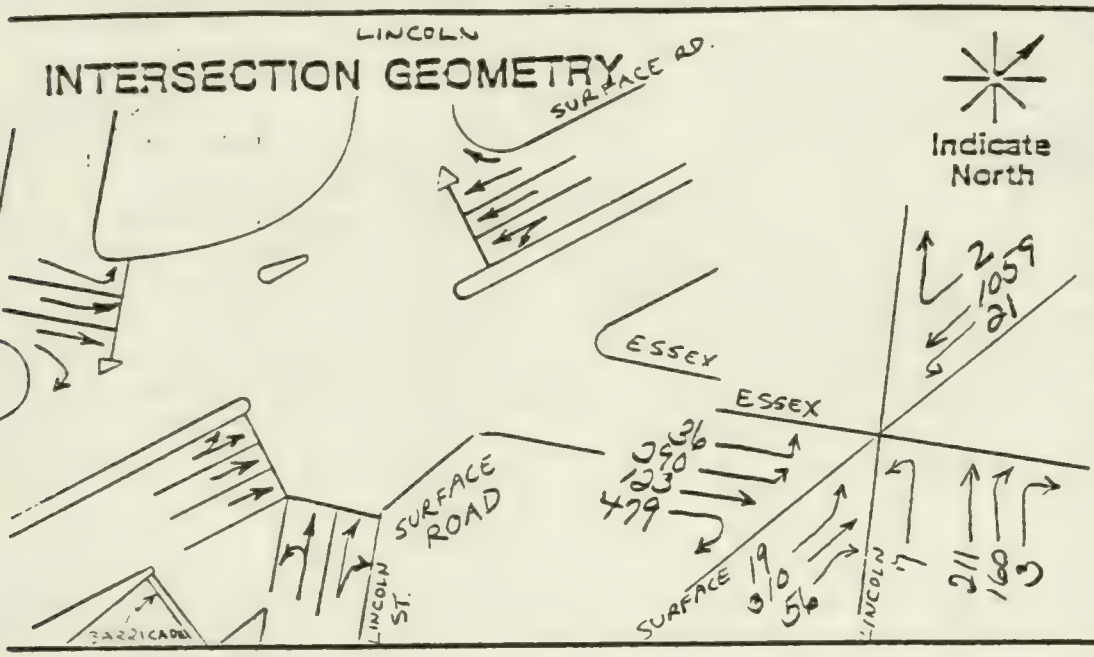
INTERSECTION ESSEX / LINCOLN & SURFACE
ALT. Existing YEAR 1986 PERIOD PM
CALCULATED BY IAR DATE 5/27/86 SHEET 2 OF
CHECKED BY ____ DATE ____ JOB NO. 1148
Rev. 10/14/86

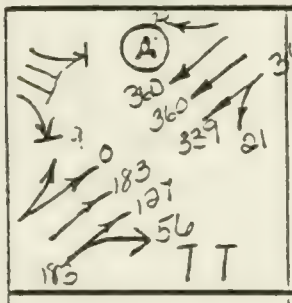
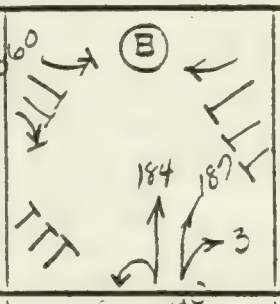
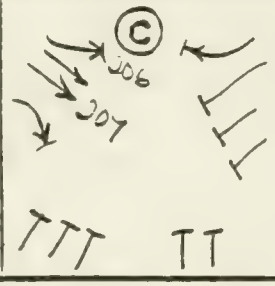
INTERSECTION GEOMETRY



Left Turn Check

	Approac 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
			PED CYCLE	
360 + 19 = 379				
CLV= 379	CLV= 191	CLV= 207	CLV=	CLV=

Note: 20% reduction in 3ϕ criteria for pedestrians

Σ CLV 777
V/C .68
LOS B

CRITERIA (vph)		2 ϕ	(3 ϕ)	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

(#3)

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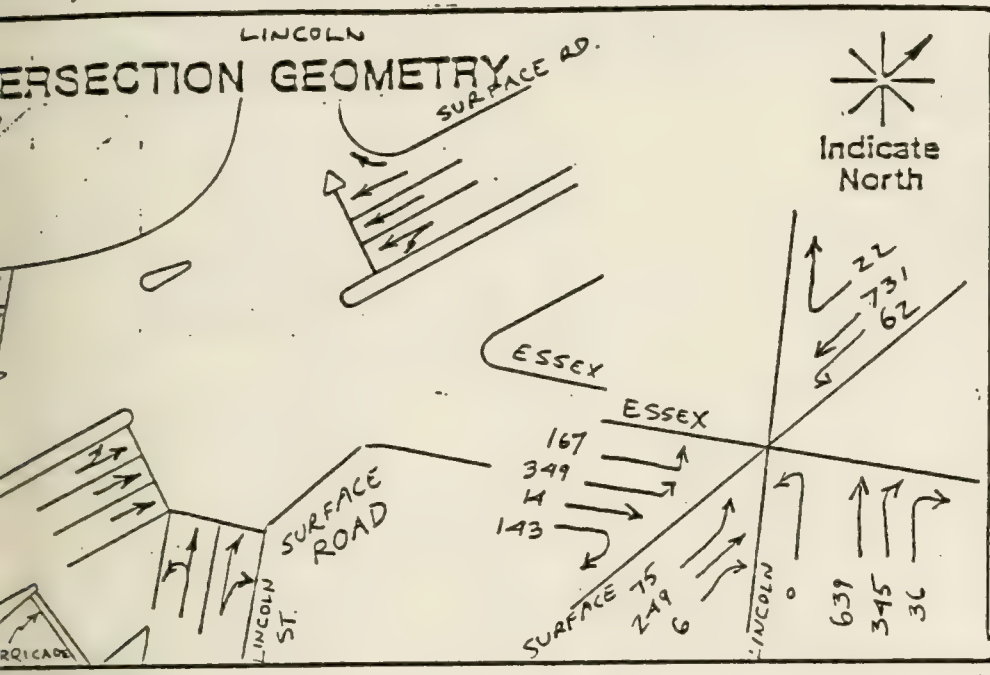
INTERSECTION ESSEX / LINCOLN & SURFACE RD.
ALT. NO BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-28-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

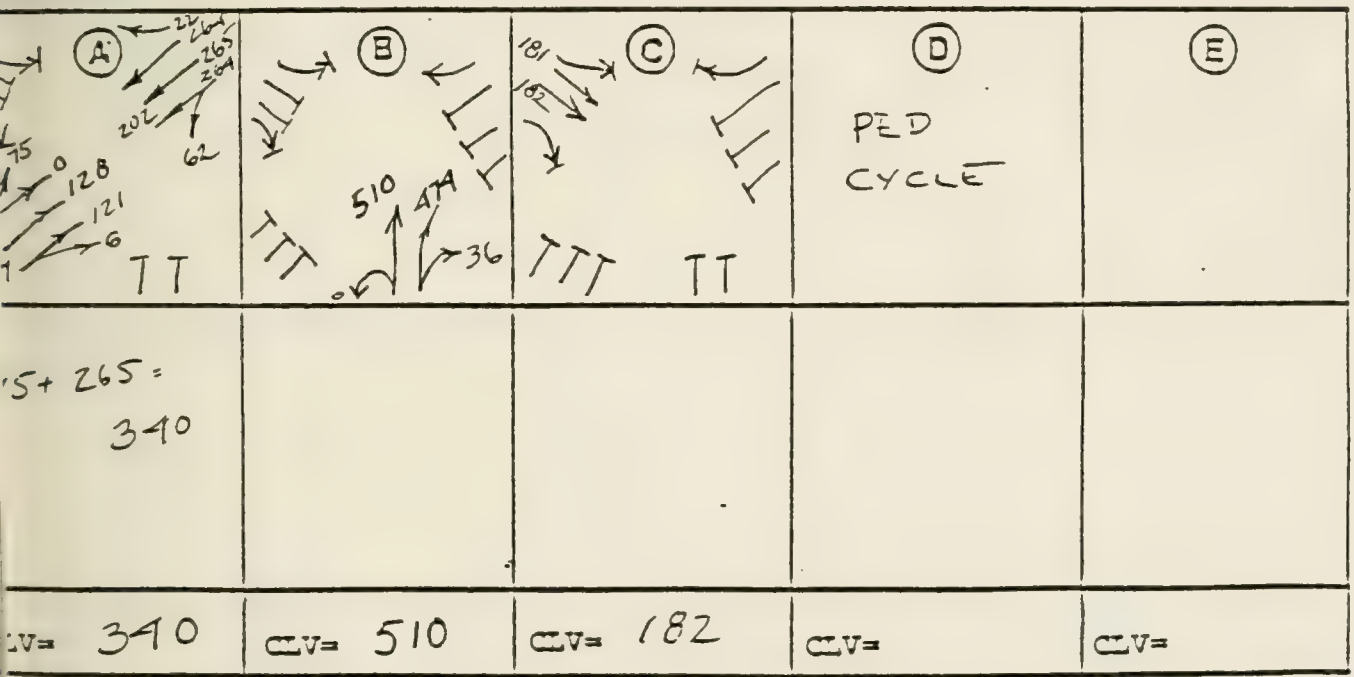
ERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

HASING



'5+ 265 = 340				
CLV= 340	CLV= 510	CLV= 182	CLV=	CLV=

Note: 20% reduction in 3ϕ criteria for pedestrians

Σ CLV 1032
V/C .90
LOS D

CRITERIA (vph)		2 ϕ	(3 ϕ)	4 ϕ
LOS	A	900	855	825
	B	1050	1000	963
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

VIA (#5)

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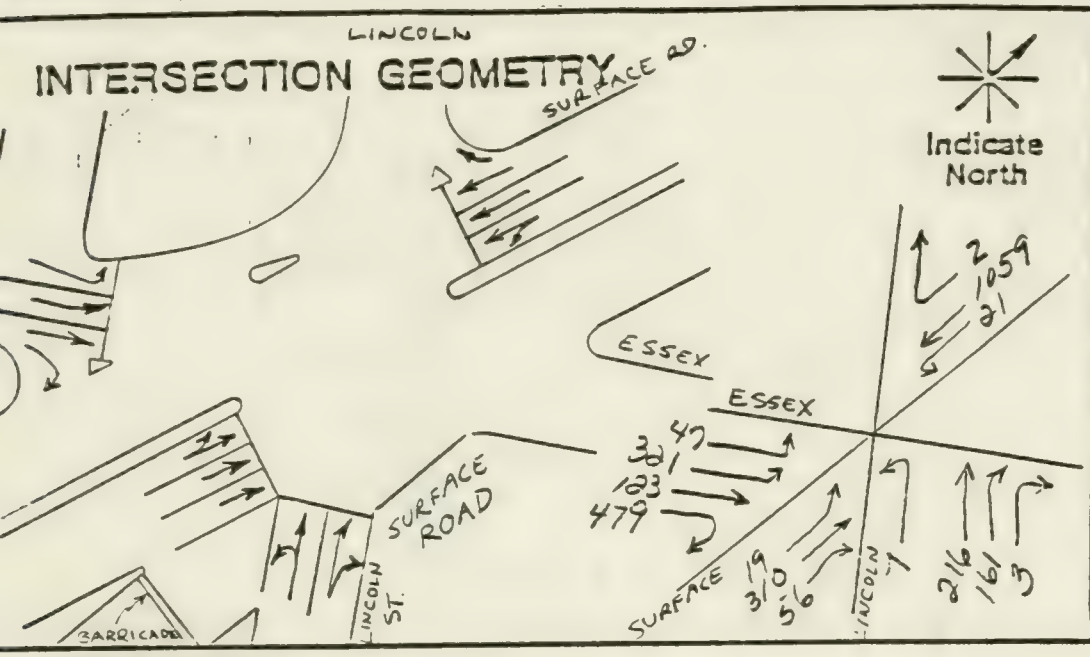
INTERSECTION ESSEX / LINCOLN & SURFACE
ALT. No Build YEAR 1987 PERIOD PM
CALCULATED BY RAR DATE 5-22-86 SHEET 4 OF
CHECKED BY _____ DATE _____ JOB NO. 148
Rev. 10/14/86

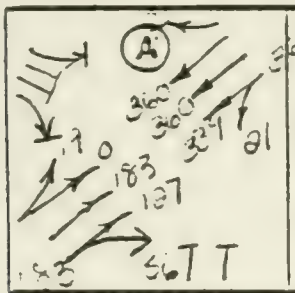
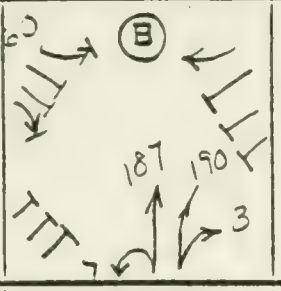
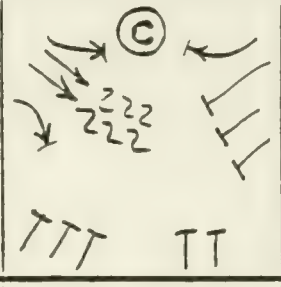
INTERSECTION GEOMETRY



Left Turn Check

	Approac 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
			PED CYCLE	
360 + 19 = 379	AT 193			
CLV= 379	CLV= 194	CLV= 222	CLV=	CLV=

Note: 20% reduction in 3ϕ criteria for pedestrians

Σ CLV 795
V/C .70
LOS B

CRITERIA (vph)		2 ϕ	(3 ϕ)	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

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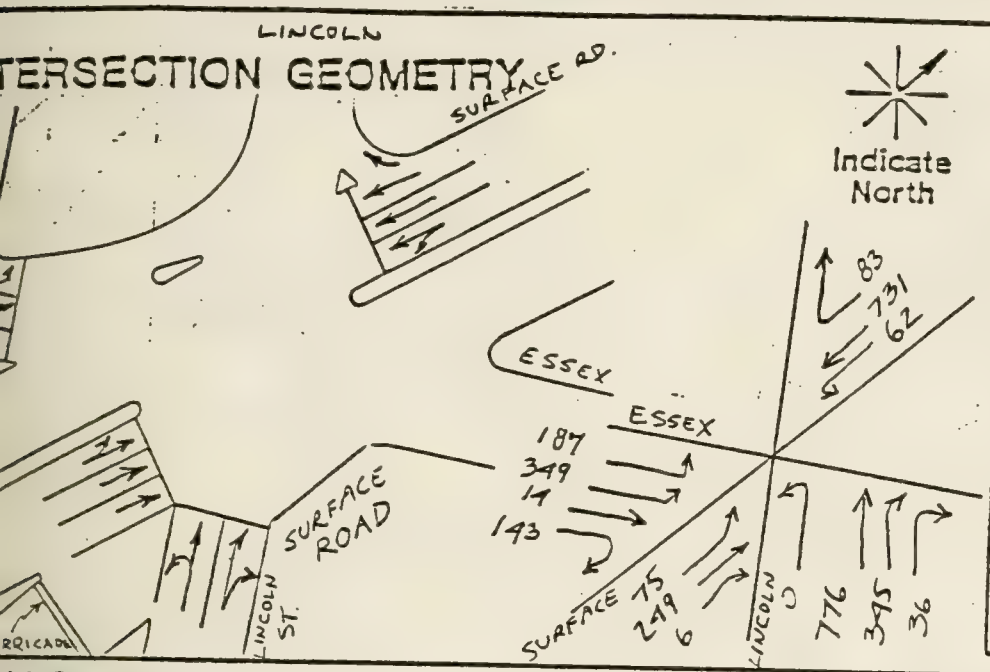
INTERSECTION ESSEX / LINCOLN & SURFACE RD.
ALT. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-28-86 SHEET 5 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

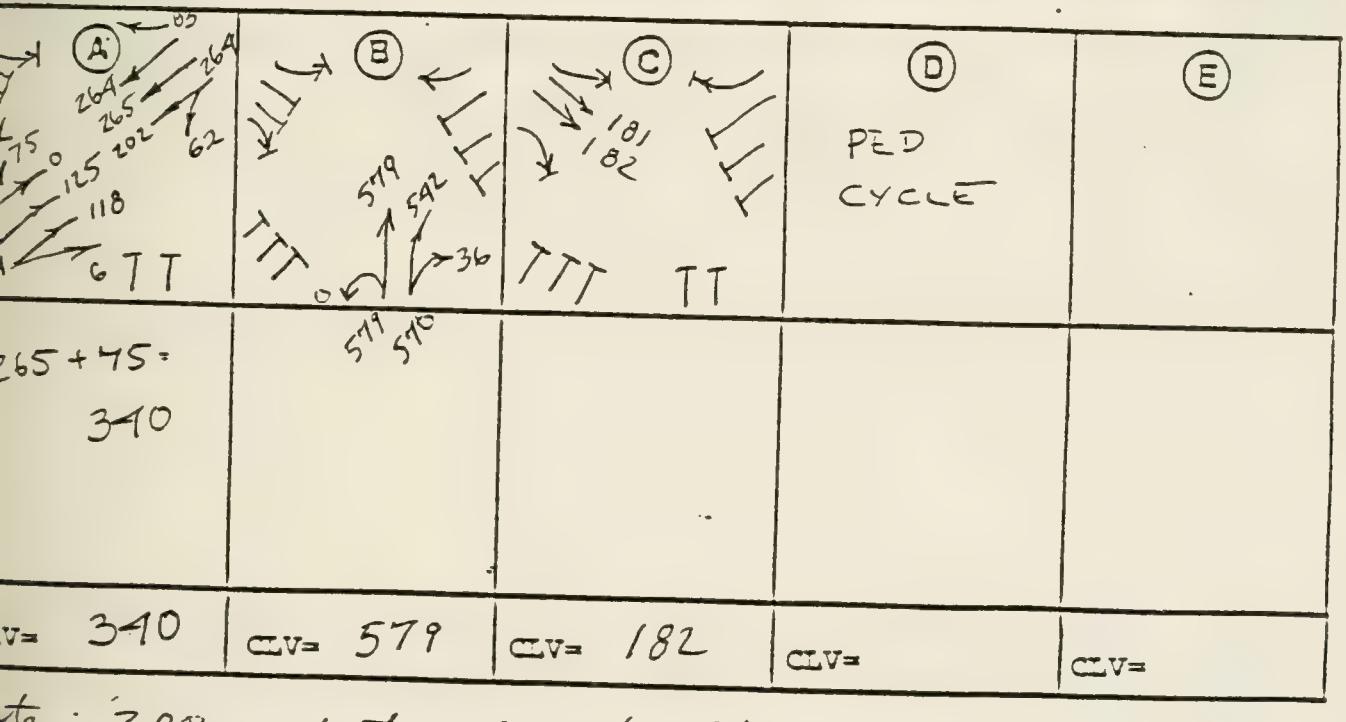
TERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING



Note: 20% reduction in 3φ criteria for pedestrians

Σ CLV 1101
V/C .97
LOS E

CRITERIA (vph)		2 φ	3 φ	4 φ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

V/C (#5)

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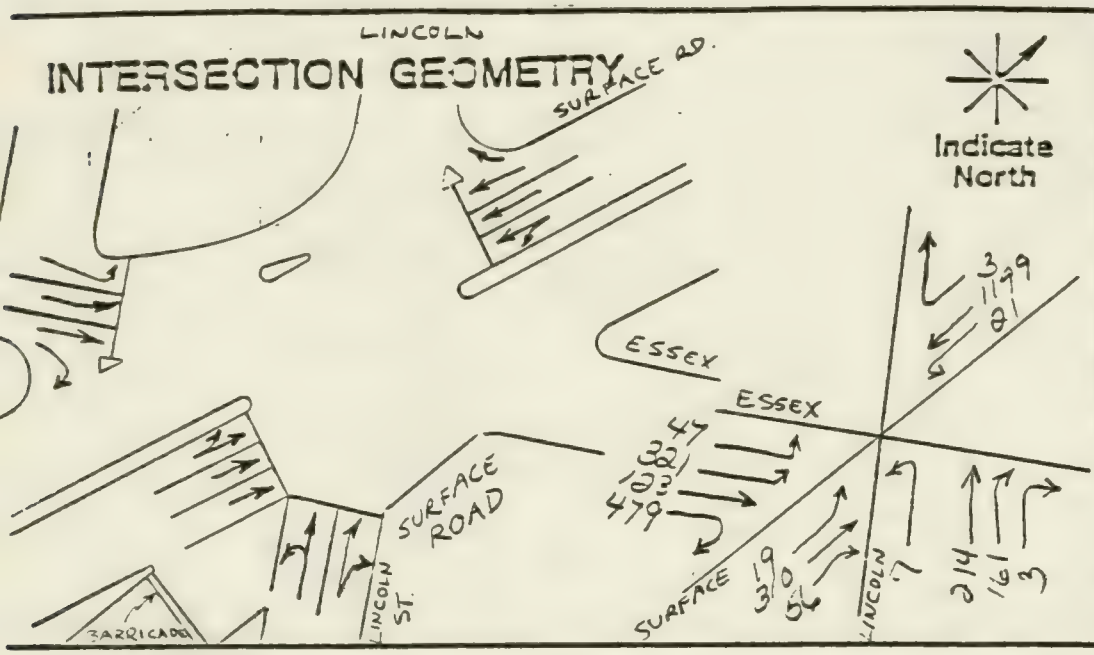
INTERSECTION ESSEX / LINCOLN & SURFACE
ALT. Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5-28-86 SHEET 6 OF
CHECKED BY _____ DATE _____ JOB NO. 148
Rev 10/14/86

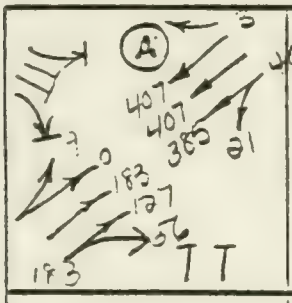
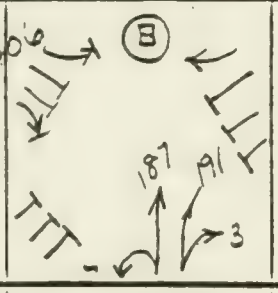
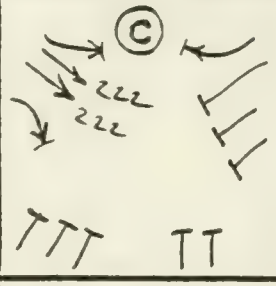
INTERSECTION GEOMETRY



Left Turn Check

	Approac 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

A	B	C	D	E
			PED CYCLE	
19 + 407 = 426				
CLV= 426	CLV= 194	CLV= 222	CLV=	CLV=

Note: 20% reduction in 3ϕ criteria for pedestrians

Σ CLV 842
V/C .74
LOS C

CRITERIA (vph)		2 ϕ	(3 ϕ)	4 ϕ
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

#7

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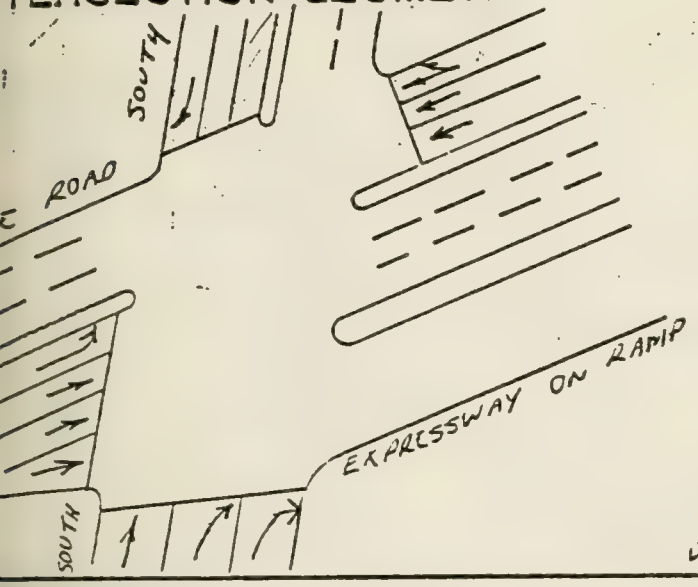
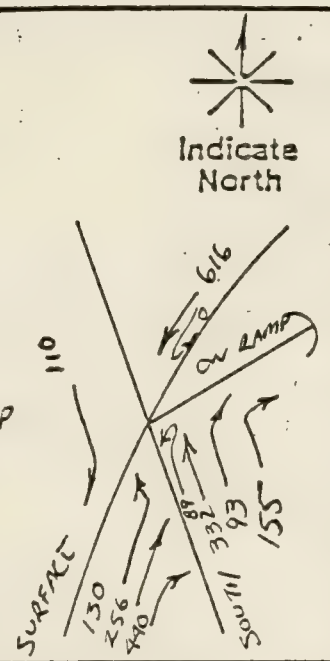
INTERSECTION SOUTH & SURFACE ROAD
ALT. EXISTING YEAR 1986 PERIOD A.M.
CALCULATED BY RAR DATE 5-22-86 SHEET 1 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

TERSECTION GEOMETRY

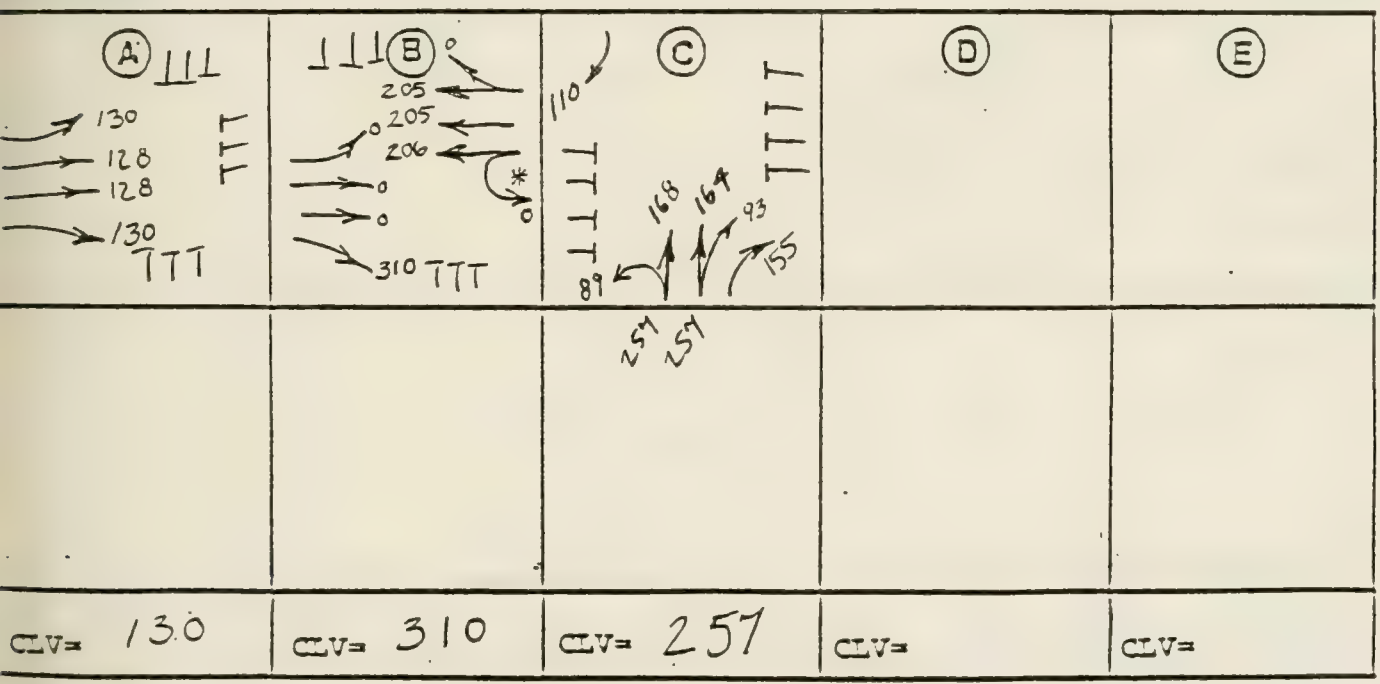




Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING



CLV= 130	CLV= 310	CLV= 257	CLV=	CLV=

* illegal turn on to expressway ramp
Note: 20% reduction in 3Ø criteria due to pedestrians

Σ CLV 697
V/C .61
LOS B

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 (1140)	1375

VHA (#7)

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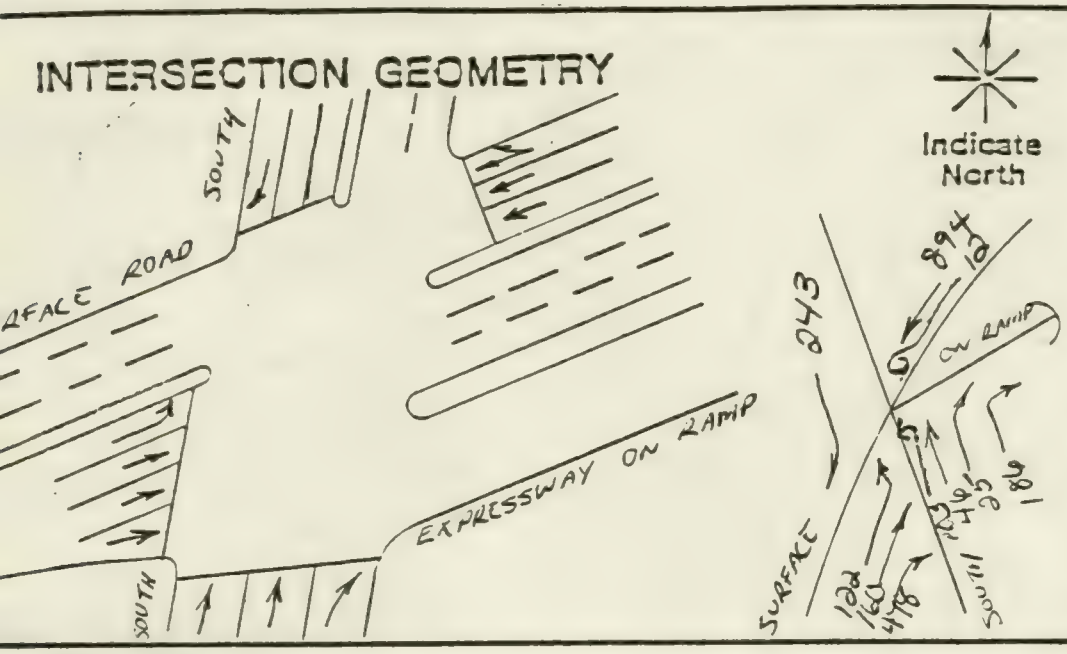
INTERSECTION SOUTH & SURFACE ROAD
ALT. Existing YEAR 1986 PERIOD PM
CALCULATED BY KHR DATE 5-22-86 SHEET 2 OF
CHECKED BY _____ DATE _____ JOB NO. 1489
Dev 10/14/86

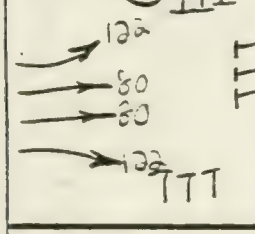
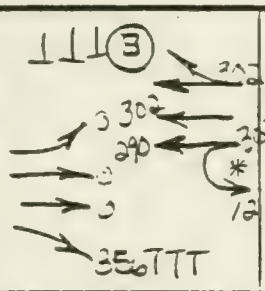
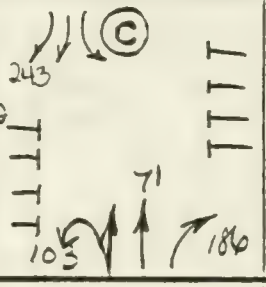
INTERSECTION GEOMETRY



Left Turn Check

	Approac 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING

(A)	(B)	(C)	(D)	(E)
				
		103 + 243 = 346		
CLV= 122	CLV= 368	CLV= 346	CLV=	CLV=

* illegal turn on to expressway ramp

Note: 20% reduction in 3Ø criteria due to pedestrians

Σ CLV 836
V/C .73
LOS C

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

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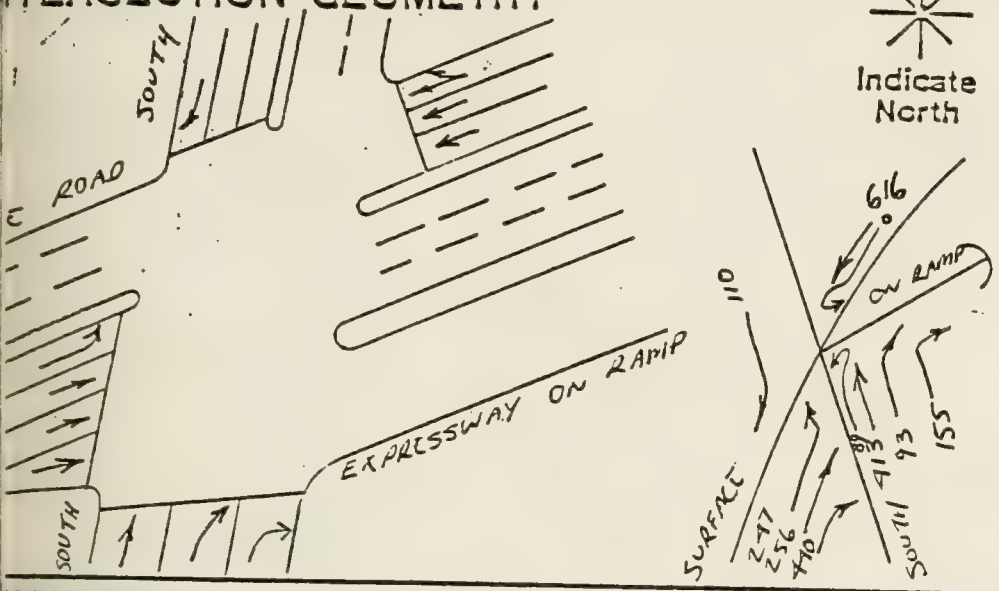
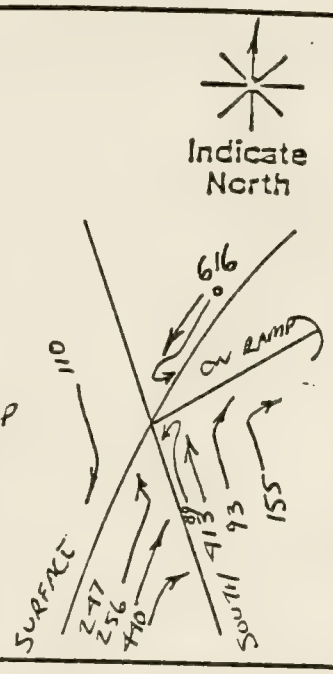
INTERSECTION SOUTH & SURFACE ROAD
ALT. NO. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-22-86 SHEET 3 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY





Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING

A	B	C	D	E
247 TTT	205 205 206 * 193 TTT	110 TTTTT 89 209 204 93 155		
		298 297		
CLV= 247	CLV= 206	CLV= 297	CLV=	CLV=

* illegal turn on to expressway ramp

Note: 20% reduction in 3Ø criteria due to pedestrians

Σ CLV 750
V/C .66
LOS B

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 / 1140	1375

VHE (#7)

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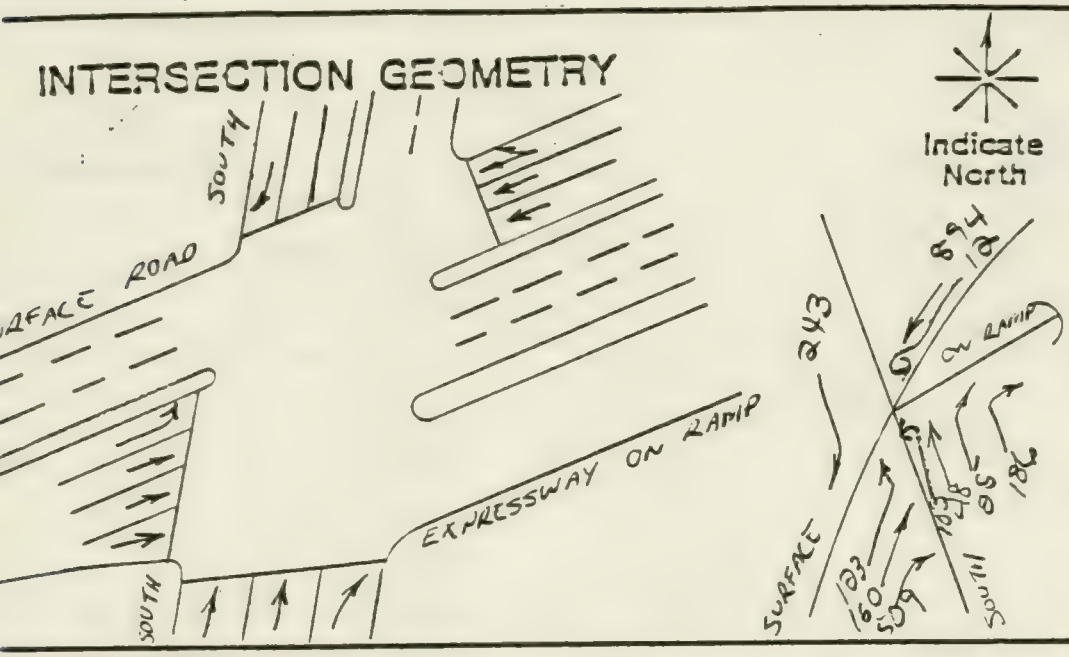
INTERSECTION SOUTH & SURFACE ROAD
ALT. No Build YEAR 1994 PERIOD PM
CALCULATED BY KAR DATE 5-22-86 SHEET 4 OF
CHECKED BY _____ DATE _____ JOB NO. 1489
Rev. 10/14/86

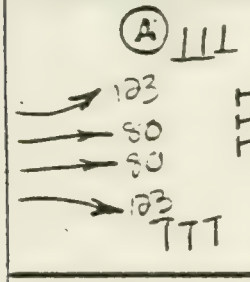
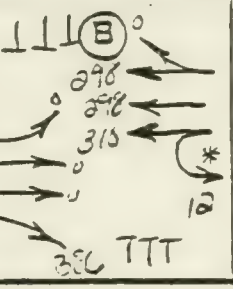
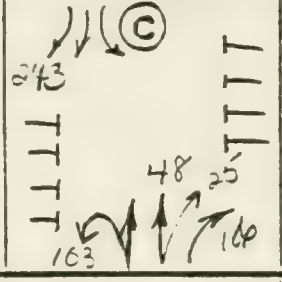
INTERSECTION GEOMETRY



Left Turn Check

	Approac 1	2
a. Number of change intervals per hour		
b. Left turn capacity on change interval, in vph		
c. G/C Ratio		
d. Opposing volume in vph		
e. Left turn capacity on green, in vph		
f. Left turn capacity in vph (b + c)		
g. Left turn volume in vph		
h. Is volume > capacity (g > f)?		

PHASING

(A)	(B)	(C)	(D)	(E)
				
	386 + 12 = 398	163 + 243 = 346		
CLV= 123	CLV= 398	CLV= 346	CLV=	CLV=

* illegal turn on to expressway ramp

Note: 20% reduction in 3Ø criteria due to pedestrians

Σ CLV 867

V/C .71

LOS C

CRITERIA (vph)		2 Ø	(3 Ø)	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

(#7)

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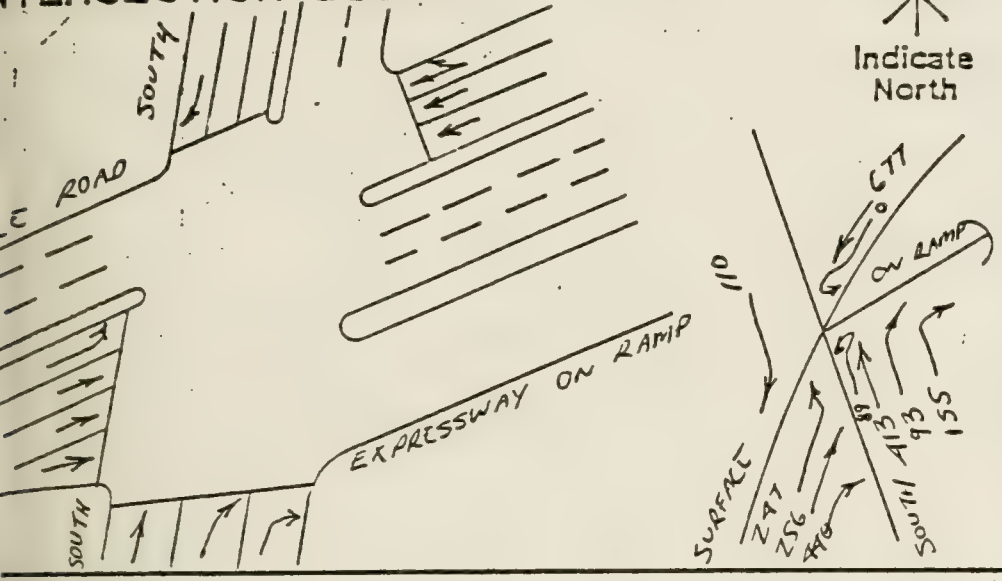
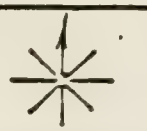
INTERSECTION SOUTH & SURFACE ROAD.
ALT. BUILD YEAR 1989 PERIOD AM
CALCULATED BY RAR DATE 5-22-86 SHEET 5 OF 6
CHECKED BY _____ DATE _____ JOB NO. 1489

INTERSECTION GEOMETRY

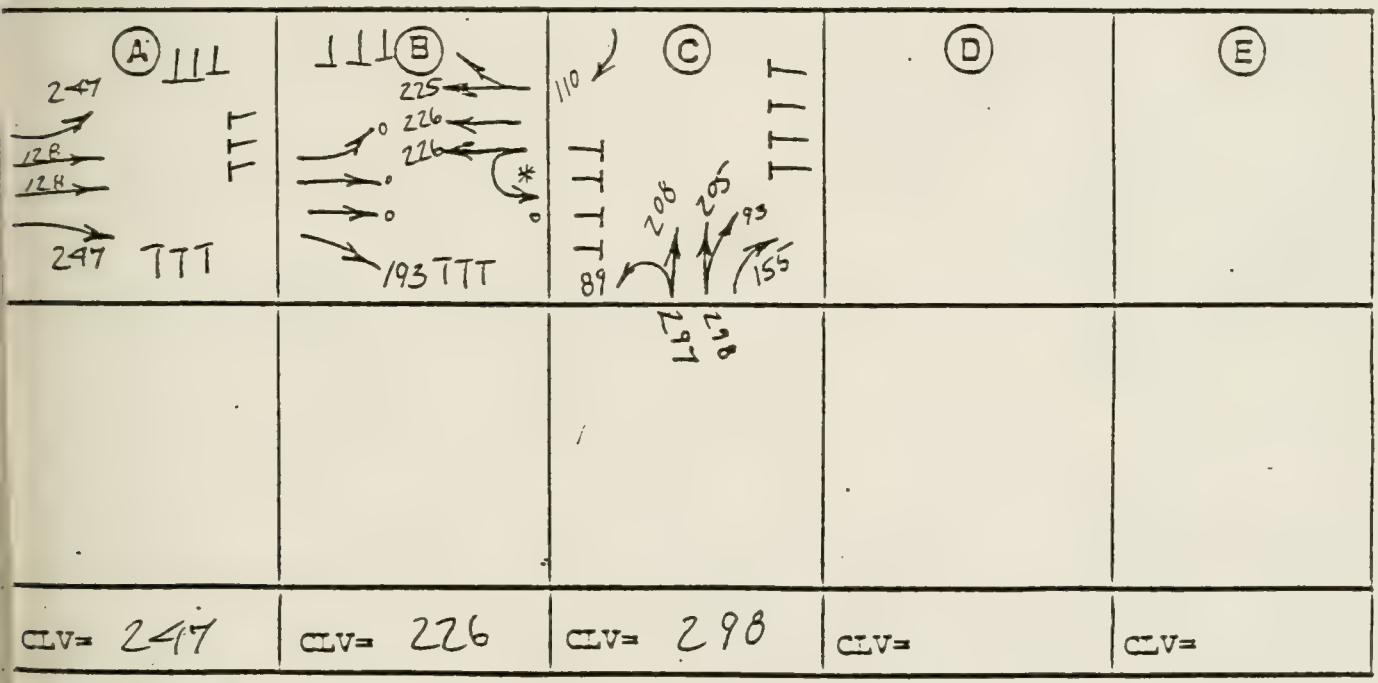




Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

PHASING



CLV= 247	CLV= 226	CLV= 298	CLV=	CLV=

* illegal turn on to expressway ramp

Note: 20% reduction in 3Ø criteria due to pedestrians

Σ CLV 771
V/C .67
LOS B

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425 (1140)	1375

VH (#7)

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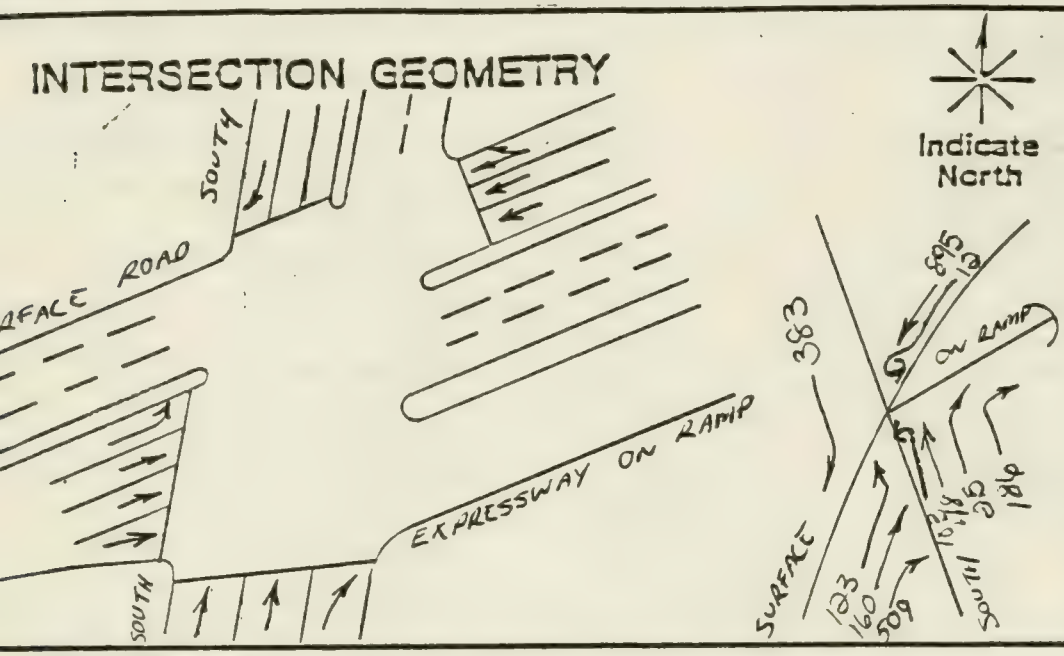
INTERSECTION SOUTH & SURFACE ROAD
ALT. Build YEAR 1989 PERIOD PM
CALCULATED BY RAR DATE 5-22-86 SHEET 6 OF
CHECKED BY DATE JOB NO. 1489

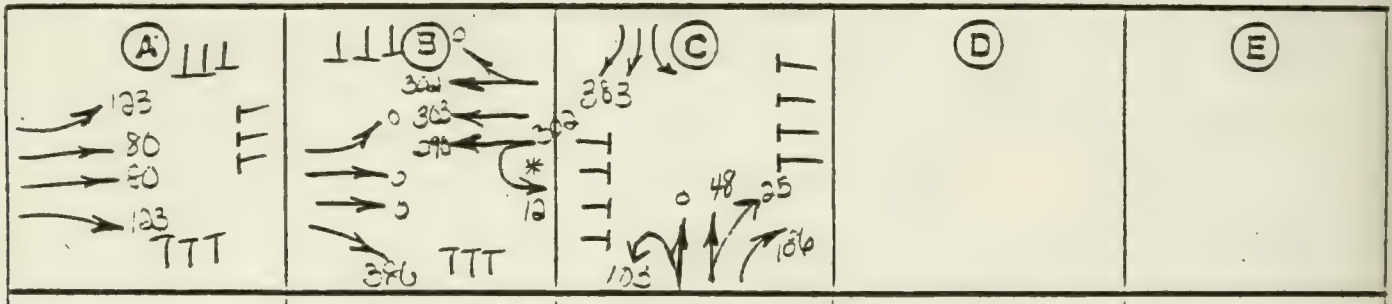
INTERSECTION GEOMETRY



Left Turn Check

	Approach 1	2	3
a. Number of change intervals per hour			
b. Left turn capacity on change interval, in vph			
c. G/C Ratio			
d. Opposing volume in vph			
e. Left turn capacity on green, in vph			
f. Left turn capacity in vph (b + c)			
g. Left turn volume in vph			
h. Is volume > capacity (g > f)?			

PHASING



	386 + 12 = 398	383 + 103 = 486		
CLV= 123	CLV= 398	CLV= 486	CLV=	CLV=

* illegal turn on to expressway ramp

Note: 20% reduction in 3Ø criteria due to pedestrians

Σ CLV 1007
V/C .68
LOS D

CRITERIA (vph)		2 Ø	3 Ø	4 Ø
LOS	A	900	855	825
	B	1050	1000	965
	C	1200	1140	1100
	D	1350	1275	1225
	E	1500	1425	1375

1140

APPENDIX C

C.1 Motor Vehicle Emissions

Motor vehicle emission rates used in this analysis were generated by the EPA MOBILE3 computer program*. Modeling runs were based on the MOBILE3 default national motor vehicle mix (see Table C.1) and an average December temperature of 33°F. The 1985 Massachusetts registration distribution for light duty vehicles, light duty trucks, and heavy duty trucks (see Table C.2) was used for the existing year while the MOBILE3 default registration distribution was assumed for future cases. The MOBILE3 default national cold/hot start mix (presented in Table C.3) was used for determining roadway emissions during the peak eight-hour period. A mix with a higher cold start percentage for the rush hour was used to represent the peak one-hour period (see Table C.4). Emission rates are based on peak one-hour and eight-hour travel speeds for vehicles approaching each intersection as estimated from field surveys. Table C.5 presents the composite free-flow emission rates for the peak one-hour and eight-hour periods. Idle mode emission rates for development of the linear queuing source strength were calculated based on a 5 mph vehicle speed and peak 1- and 8-hour vehicle operating conditions as described above. These are shown in Table C.6. The MOBILE3 idle mode emission rates were not considered as they reflect only hot stabilized conditions. The effect of the statewide inspection/maintenance (I/M) program was incorporated and included a program implemented in 1983, a 13% stringency level, no mechanic training, an earliest model year of 15 years prior to the analysis year, vehicle type categories of LDGV, LDGT1 and LDGT2, and an idle test with cut points of 1.2% and 220 ppm for CO and HC, respectively. In addition, no alternative I/M credits or anti-tampering program was assumed. The complete MOBILE3 output is found following Table C.20.

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* EPA, User's Guide to MOBILE3: Mobile Source Emissions Model, EPA-460/3-84-002, Ann Arbor, MI, June, 1984.

C.2 CALINE3 Model

For each year and intersection studied, the FHWA CALINE3* computer program was used to predict CO concentrations at sensitive receptor locations. Queue lengths utilized in the analysis were developed from worksheet 2 of the EPA Volume 9 Indirect Source Guidelines**. The Volume 9 worksheets are included at the end of this Appendix.

The CALINE3 intersection analysis involved superimposing motor vehicle idling emissions of queue links on free flow links. Based on EPA recommendations, the only modification to these procedures was that a queue length of six meters instead of eight meters was used***. For overcapacity situations, queue lengths were calculated using the National Cooperative Highway Research Program Report #133 technique as suggested by EPA Region I***.

The modeling runs were supplemented by a set of assumptions consistent with DEQE and BRA requirements. Worst case meteorological conditions of Pasquill-Gifford Class D stability combined with wind speeds of 1.0 and 1.3 m/s for peak 1-and 8-hour periods. A winter mixing height of 850 meters**** and an ambient air temperature of 33°F were used. These meteorological data are appropriate for a December day during which peak CO concentrations are expected to occur. For each intersection, the full range of wind directions at 10 degree intervals was examined. In addition, a surface roughness (Z_o)

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* FHWA, CALINE3 - A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets, FHWA/CA/TL-79/23, November, 1979.

** EPA, Guidelines for Air Quality Maintenance Planning and Analysis Volume 9 (Revised): Evaluating Indirect Sources, Second Printing, EPA-450/4-78-001, Research Triangle Park, NC, September, 1978.

*** EPA Region I, Region I Mobile Source Modeling Procedures, January 1, 1985.

**** Holzworth, G.C., Mixing heights, Wind Speeds, and Potential for Urban Air Quality Throughout the Contiguous United States, USEPA, AP-101, January, 1972.

of 321 cm (defined by CALINE3 for central business districts), and settling and deposition velocities of 0.0 cm/s were incorporated. Due to the large amount of model output, hardcopy will be provided for review upon request.

C.3 Parking Garage Analysis

A separate analysis was performed to determine impacts of the project's proposed 5 level-238 space underground parking garage. The parking facility analysis predicted maximum 1-hour and 8-hour CO concentrations, for the 1989 build configuration, using the EPA MOBILE3, EPA Indirect Source Guidelines and Halitsky's gas diffusion equations. Concentrations were calculated at all receptor locations, in conjunction with a worst case 1-hour wind speed of 1.0 m/s and eight-hour speed of 1.3 m/s.

The underground parking garage will be serviced by five forced air ventilation units. The exhaust vents will be located on the roof of the five story base structure. One exhaust vent will be located at the building corner near the Summer Street/South Street intersection (Stack 1). The four other stacks are located along the building side facing Lincoln Street. Each exhaust vent will have a total area of 17.36 square feet with a flow rate of 21,000 cfm. In the analysis, stacks 2 and 3 were assumed co-located as were stacks 4 and 5 due to their close proximity of each other. For each of the co-located stacks, the contribution of one stack was doubled.

Emissions were estimated using Worksheet 3 of the EPA Indirect Source Guidelines. These worksheets are included at the end of this Appendix. The ventilation system will emit a total of 2.56 g/s of CO during the peak AM 1-hour period, 2.63 g/s of CO during peak PM 1-hour period, and 0.18 g/s of CO during the 8-hour period.

The concentration of CO in the ventilation system exhaust was determined by the following formula:

$$X = 870\ (Q + (X_b)(F))/F$$

where:

X = CO concentration in the ventilation exhaust (ppm)

Q = CO emission rate for the vent system (g/s)

X_b = Background concentration of CO in the makeup air assumed equal to the 1989 background concentrations used in this analysis (g/m^3)

F = Volumetric flow rate (m^3/s)

Background concentrations of 6.0 ppm and 3.6 ppm were used for the 1-hour and 8-hour periods. These levels are equivalent to 6.90 (10^{-3}) and 4.14 (10^{-3}) g/m^3, respectively. Concentrations of CO in each exhaust vent are predicted to be:

X = 50.95 ppm (1-Hour AM)
= 52.18 ppm (1-Hour PM)
= 6.76 ppm (8-Hour)

For near-field receptors such as those being considered, ambient concentrations were scaled from the ventilation air concentrations using Halitsky's empirical model for gas diffusion near buildings. This model states that the ambient concentration X_a equals:

$$X_a = X/D$$

where D is a dilution factor defined as follows:

$$D = 2.22\ M \left[3.16 + \frac{0.1(S)}{(Ae)^{1/2}}\right]^2 \frac{V}{Ve}$$

The terms are defined as follows:

M = building configuration factor, equal to 4.0 for ground-level receptors in the cavity of the exhaust plume

S = shortest arc distance from source to receptor (m)

Ae = area of an exhaust opening, $1.61m^2$

V = ambient wind velocity,
= 1.0 m/s (1-Hour)
= 1.3 m/s (8-Hour)

Ve = source exit velocity, 6.16 m/s

Tables C.7 through C.12 summarize the model input parameters and results for each receptor examined for the one-hour and eight-hour periods. These values represent actual physical characteristics of the ventilation system as presented above, source-receptor geometry, and worst case wind conditions.

C.4 Dewey Square Tunnel Ventilation Building Analysis

In order to address potential impacts of pollutants emitted from the adjacent ventilation buildings, Halitsky's gas diffusion equation was used to examine CO concentrations at each receptor location for the existing and future cases.

Travel speed, tunnel length and traffic volumes were obtained from the Third Harbor Tunnel/Central Artery EIS*. Pollutant emissions were computed using the EPA MOBILE3 program for the central artery (at 26 mph), and are as follows:

	Emissions (grams/vehicle-mile)	
	1-hour	8-hour
1986	51.46	32.88
1989	40.16	25.40

Based on these emission factors, traffic volumes, and the length of tunnel serviced by these ventilation buildings**, the following emission rates were calculated:

		Emission Rates (g/s) [Traffic Volumes]***	
Ventilation Building		1-hour	8-hour
Southbound	1986	17.6 [5524]	9.2 [4530]
	1989	15.7 [6293]	8.1 [5160]
Northbound	1986	15.7 [4910]	8.2 [4026]
	1989	13.6 [5446]	7.0 [4466]

The concentration of CO in the ventilation systems was when determined with the following formula:

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* FHWA and MDPW, Final EIS: Third Harbor Tunnel Interstate 90/Central Artery, Interstate 93, FHWA-MA-EIS-82-02-F, August 1985 (Appendices).

** There are a total of four ventilation buildings servicing the Dewey Square Tunnel. It is assumed the two vents near the project site service half the total 0.447 miles of tunnel, or 0.2235 miles.

*** Bracketed numbers are traffic volumes.

$$X = 870\ (Q+(X_b)(F))/F$$

where:

X = CO concentration in the ventilation exhaust (ppm)

Q = CO emission rate for the vent system (g/s)

X_b = Background concentration of CO in the makeup air assumed equal to the 1989 background concentrations used in this analysis (g/m^3)

F = Volumetric flow rate (m^3/s)

Background concentrations of 6.0 ppm and 3.6 ppm were used for the 1-hour and 8-hour periods. These levels are equivalent to 6.90 (10^{-3}) and 4.14 (10^{-3}) g/m^3, respectively. A flow rate of 560 m^3/s was used for the southbound ventilation building and 710 m^3/s for the northbound ventilation building.* Concentrations of CO in each vent are predicted to be:

		Concentration (X)(grams/cubic meter)	
Ventilation Building		1-hour	8-hour
Southbound	1986	33.34	17.89
	1989	30.39	16.18
Northbound	1986	25.24	13.65
	1989	22.67	12.18

* Ref EIS.

For near-field receptors such as those being considered, ambient concentrations were scaled from the ventilation air concentrations using Halitsky's empirical model for gas diffusion near buildings. This model states that the ambient concentrations X_a equals:

$$Xa = X/D$$

where D is a dilution factor defined as follows:

$$D = 2.22\ M \left[3.16 + \frac{0.1(S)}{(Ae)^{1/2}}\right]^2 \frac{V}{Ve}$$

The terms are as follows:

M	=	building configuration factor, equal to 4.0 for ground-level receptors in the cavity of the exhaust plume
S	=	shortest arc distance from source to receptor (m)
Ae	=	area of an exhaust opening, 116 m^2
V	=	ambient wind velocity,
	=	1.0 m/s (1-Hour)
	=	1.3 m/s (8-Hour)
Ve	=	source exit velocity, 4.8 m/s (Southbound Vent) 6.1 m/s (Northbound Vent).

Tables C.13-C.20 summarize the model input parameters and results for each receptor examined for the one-hour and eight-hour periods. The values represent actual physical characteristics of the ventilation system and presented above, source-receptor geometry, and worst case wind conditions.

TABLE C.1

NATIONWIDE AVERAGE

MOTOR VEHICLE MIX BY TYPE*

Vehicle Type	Percentage of VMT	
	1986	1989
ight-Duty Gasoline Vehicles (LDGV)	65.7	64.0
ight-Duty Gasoline Trucks		
0-6000 lb GVW** (LDGT1)	13.0	11.8
Over 6000 lb GVW (LDGT2)	9.0	8.6
eavy-Duty Gasoline Trucks (HDGV)	3.5	4.1
ight-Duty Diesel Vehicles (LDDV)	2.7	4.1
ight-Duty Diesel Trucks (LDDT)	0.9	1.8
eavy-Duty Diesel Trucks (HDDT)	4.4	4.9
otorcycles (MC)	0.7	0.7

EPA, User's Guide to MOBILE3: Mobile Source Emissions Model, EPA-460/3-84-002, Ann Arbor, MI, June, 1984.

* Gross vehicle weight.

TABLE C.2

1985 MASSACHUSETTS VEHICLE REGISTRATION DISTRIBUTION

Vehicle Age in Years	Percent of Total Vehicles		
	LDGV,LDDV	LDGT,LDDT	HDT (Gas & Diesel)
1	7.07	6.3	4.2
2	10.13	6.9	7.2
3	8.51	5.8	5.4
4	7.74	5.9	5.3
5	7.96	12.6	8.4
6	8.36	9.8	10.0
7	8.40	8.8	8.2
8	7.88	6.5	6.2
9	6.65	4.6	4.8
10	6.00	6.6	6.4
11	6.00	5.7	6.4
12	5.00	4.6	7.8
13	3.00	3.4	3.8
14	2.00	2.7	3.2
15	1.50	2.2	3.0
16	1.10	1.8	2.4
17	0.90	1.7	2.1
18	0.70	1.6	1.9
19	0.60	1.4	1.8
20 +	0.50	1.1	1.5
Total	100.0	100.0	100.0

Source: Massachusetts Department of Environmental Quality Engineering

TABLE C.3

NATIONWIDE AVERAGE

COLD/HOT START MIX FOR MOTOR VEHICLES

Vehicles Cold Start Mode	20.6%
Vehicles Hot Start Mode	27.3%
Vehicles Hot Stabilized Mode	52.1%
Total	100.0%

TABLE C.4

RUSH HOUR COLD/HOT

START MIX FOR MOTOR VEHICLES

Vehicles Cold Start Mode	50.0%
Vehicles Hot Start Mode	10.0%
Vehicles Hot Stabilized Mode	40.0%
Total	100.0%

TABLE C.5

COMPOSITE CO EMISSION RATES

Averaging Period	Roadway	Speed (mph)	CO Emissions Rate (grams/mile) 1986	1989
1-Hour	Congress & Atlantic @ Congress/Atlantic Intersection	17	81.27	61.24
	Atlantic & Summer @ Atlantic/Summer Intersection	14	95.26	71.41
	All Others	12	107.20	79.84
8-Hour	Congress/Atlantic	25	35.48	21.58
	All Others	18	49.44	36.93

TABLE C.6

IDLE MODE EMISSION RATES

Averaging Period	CO Emission Rate (grams/minute) 1986	1989
1-Hour	16.25	11.35
8-Hour	10.52	7.30

TABLE C.7

PROPOSED PARKING GARAGE ANALYSIS

EXHAUST STACK 1

INPUTS AND MAXIMUM 1-HOUR IMPACTS*

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	584	3,487	.02
	AS2	Cafe Area	584	3,487	.02
	AS3	T Entrance	416	1,863	.03
	AS4	T Entrance	584	3,487	.02
Congress/Atlantic	CA1	Bus Terminal	953	8,831	.01
	CA2	IFR Furniture	1,132	12,301	.004
	CA3	Doorway	1,132	12,301	.004
	CA4	Fed Res Bank	1,042	10,484	.01
Essex/Lincoln/ Surface**	ELS1	Project Corner	139	287	.18
	ELS2	Retail Shop	318	1,148	.04
	ELS3	Parking Lot	279	912	.06
Kneeland/Surface	KS1	Bus Stop	1,162	12,938	.004
	KS2	Parking Area	1,322	16,612	.003
South/Surface	SS1	Project Corner	81	131	.40
	SS2	Crosswalk	114	213	.25
	SS3	Artery Vent	184	450	.12
	SS4	Bus Stop	106	191	.27

* $\overline{X}$ = 50.95 ppm (AM); 52.18 ppm (PM)
V = 1.0 m/s
Ve = 6.16 m/s
Ae = 1.61 m^2
M = 4.0

** AM peak hour used for intersection analysis

TABLE C.8

PROPOSED PARKING GARAGE ANALYSIS

EXHAUST STACKS 2 & 3

INPUTS AND MAXIMUM 1-HOUR IMPACTS*

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	584	3,487	.03
	AS2	Cafe Area	614	3,831	.03
	AS3	T Entrance	465	2,284	.05
	AS4	T Entrance	614	3,831	.03
Congress/Atlantic	CA1	Bus Terminal	933	8,478	.01
	CA2	IFR Furniture	1,142	12,512	.01
	CA3	Doorway	1,142	12,512	.01
	CA4	Fed Res Bank	1,052	10,679	.01
Essex/Lincoln/ Surface**	ELS1	Project Corner	396	1,703	.06
	ELS2	Retail Shop	505	2,660	.04
	ELS3	Parking Lot	445	2,107	.05
Kneeland/Surface	KS1	Bus Stop	1,272	15,415	.01
	KS2	Parking Area	1,392	18,363	.01
South/Surface	SS1	Project Corner	156	344	.30
	SS2	Crosswalk	175	414	.25
	SS3	Artery Vent	298	1,023	.10
	SS4	Bus Stop	212	569	.18

* $\bar{X}$ = 101.90 ppm (AM); 104.36 ppm (PM)
V = 1.0 m/s
Ve = 6.16 m/s
Ae = 1.61 m^2
M = 4.0

** AM peak hour used for intersection analysis

TABLE C.9

PROPOSED PARKING GARAGE ANALYSIS

EXHAUST STACKS 4 & 5

INPUTS AND MAXIMUM 1-HOUR IMPACTS*

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	693	4,812	.02
	AS2	Cafe Area	674	4,566	.02
	AS3	T Entrance	564	3,268	.03
	AS4	T Entrance	703	4,944	.02
Congress/Atlantic	CA1	Bus Terminal	1,022	10,109	.01
	CA2	IFR Furniture	1,232	14,489	.01
	CA3	Doorway	1,232	14,489	.01
	CA4	Fed Res Bank	1,152	12,724	.01
Essex/Lincoln/ Surface**	ELS1	Project Corner	308	1,085	.09
	ELS2	Retail Shop	416	1,862	.05
	ELS3	Parking Lot	328	1,213	.08
Kneeland/Surface	KS1	Bus Stop	1,222	14,262	.01
	KS2	Parking Area	1,392	18,363	.01
South/Surface	SS1	Project Corner	212	569	.18
	SS2	Crosswalk	231	658	.16
	SS3	Artery Vent	357	1,412	.07
	SS4	Bus Stop	279	912	.11

* $\overline{X}$ = 101.90 ppm (AM); 104.36 ppm (PM)
V = 1.0 m/s
Ve = 6.16 m/s
Ae = 1.61 m^2
M = 4.0

** AM peak hour used for intersection analysis

TABLE C.10

PROPOSED PARKING GARAGE ANALYSIS

EXHAUST STACK 1

INPUTS AND MAXIMUM 8-HOUR IMPACTS*

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	584	4,534	.002
	AS2	Cafe Area	584	4,534	.002
	AS3	T Entrance	416	2,421	.003
	AS4	T Entrance	584	4,534	.002
Congress/Atlantic	CA1	Bus Terminal	953	11,480	.001
	CA2	IFR Furniture	1,132	15,991	.001
	CA3	Doorway	1,132	15,991	.001
	CA4	Fed Res Bank	1,042	13,629	.001
Essex/Lincoln/ Surface	ELS1	Project Corner	139	373	.02
	ELS2	Retail Shop	318	1,492	.004
	ELS3	Parking Lot	279	1,186	.01
Kneeland/Surface	KS1	Bus Stop	1,162	16,819	.001
	KS2	Parking Area	1,322	21,596	.000
South/Surface	SS1	Project Corner	81	170	.04
	SS2	Crosswalk	114	277	.02
	SS3	Artery Vent	184	585	.01
	SS4	Bus Stop	106	248	.03

* X = 6.76 ppm
V = 1.3
Ve = 6.16
Ae = 1.61 m^2
M = 4.0

TABLE C.11

PROPOSED PARKING GARAGE ANALYSIS

EXHAUST STACKS 2 & 3

INPUTS AND MAXIMUM 8-HOUR IMPACTS*

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	584	4,534	.003
	AS2	Cafe Area	614	4,980	.003
	AS3	T Entrance	465	2,970	.005
	AS4	T Entrance	614	4,980	.003
Congress/Atlantic	CA1	Bus Terminal	933	11,022	.001
	CA2	IFR Furniture	1,142	16,265	.001
	CA3	Doorway	1,142	16,265	.001
	CA4	Fed Res Bank	1,052	13,883	.001
Essex/Lincoln/ Surface	ELS1	Project Corner	396	2,214	.01
	ELS2	Retail Shop	505	3,459	.004
	ELS3	Parking Lot	445	2,739	.005
Kneeland/Surface	KS1	Bus Stop	1,272	20,039	.001
	KS2	Parking Area	1,392	23,872	.001
South/Surface	SS1	Project Corner	156	448	.03
	SS2	Crosswalk	175	538	.03
	SS3	Artery Vent	298	1,331	.01
	SS4	Bus Stop	212	740	.02

* X = 13.52 ppm
V = 1.3 m/s
Ve = 6.16 m/s
Ae = 1.61 m^2
M = 4.0

TABLE C.12

PROPOSED PARKING GARAGE ANALYSIS

EXHAUST STACKS 4 & 5

INPUTS AND MAXIMUM 8-HOUR IMPACTS*

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	693	6,256	.002
	AS2	Cafe Area	674	5,936	.002
	AS3	T Entrance	564	4,248	.003
	AS4	T Entrance	703	6,428	.002
Congress/Atlantic	CA1	Bus Terminal	1,022	13,130	.001
	CA2	IFR Furniture	1,232	18,836	.001
	CA3	Doorway	1,232	18,836	.001
	CA4	Fed Res Bank	1,152	16,541	.001
Essex/Lincoln/ Surface	ELS1	Project Corner	308	1,410	.01
	ELS2	Retail Shop	416	2,421	.01
	ELS3	Parking Lot	328	1,577	.01
Kneeland/Surface	KS1	Bus Stop	1,222	18,541	.001
	KS2	Parking Area	1,392	23,872	.001
South/Surface	SS1	Project Corner	212	740	.02
	SS2	Crosswalk	231	855	.02
	SS3	Artery Vent	357	1,835	.01
	SS4	Bus Stop	279	1,185	.01

* X = 13.52 ppm
V = 1.3 m/s
Ve = 6.16 m/s
Ae = 1.61 m^2
M = 4.0

TABLE C.13

DEWEY SQUARE TUNNEL SOUTHBOUND VENT

INPUTS AND MAXIMUM 1-HOUR IMPACTS*

1986

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	184	43.8	.76
	AS2	Cafe Area	230	51.9	.64
	AS3	T Entrance	139	36.6	.91
	AS4	T Entrance	193	45.4	.73
Congress/Atlantic	CA1	Bus Terminal	315	68.5	.49
	CA2	IFR Furniture	366	79.6	.42
	CA3	Doorway	360	78.2	.43
	CA4	Fed Res Bank	336	72.9	.46
Essex/Lincoln/ Surface	ELS1	Project Corner	48	24.0	1.39
	ELS2	Retail Shop	83	28.6	1.17
	ELS3	Parking Lot	68	26.6	1.25
Kneeland/Surface	KS1	Bus Stop	333	72.3	.46
	KS2	Parking Area	382	83.2	.40
South/Surface	SS1	Project Corner	31	22.0	1.52
	SS2	Crosswalk	48	24.0	1.39
	SS3	Artery Vent	46	23.8	1.40
	SS4	Bus Stop	26	21.4	1.56

* $X = 33.34$ ppm
$V = 1.0$ m/s
$Ve = 4.8$ m/s
$Ae = 116$ m^2
$M = 4.0$

TABLE C.14

DEWEY SQUARE TUNNEL SOUTHBOUND VENT

INPUTS AND MAXIMUM 8-HOUR IMPACTS*

1986

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	184	56.9	.31
	AS2	Cafe Area	230	67.5	.26
	AS3	T Entrance	139	47.6	.38
	AS4	T Entrance	193	59.0	.30
Congress/Atlantic	CA1	Bus Terminal	315	89.0	.20
	CA2	IFR Furniture	366	103.5	.17
	CA3	Doorway	360	101.7	.18
	CA4	Fed Res Bank	336	94.8	.19
Essex/Lincoln/ Surface	ELS1	Project Corner	48	31.2	.57
	ELS2	Retail Shop	83	37.2	.48
	ELS3	Parking Lot	68	34.6	.52
Kneeland/Surface	KS1	Bus Stop	333	94.0	.19
	KS2	Parking Area	382	108.2	.16
South/Surface	SS1	Project Corner	31	28.6	.62
	SS2	Crosswalk	48	31.2	.57
	SS3	Artery Vent	46	30.9	.58
	SS4	Bus Stop	26	27.8	.64

* X = 17.89 ppm
V = 1.3 m/s
Ve = 4.8 m/s
Ae = 116 m^2
M = 4.0

TABLE C.15

DEWEY SQUARE TUNNEL NORTHBOUND VENT

INPUTS AND MAXIMUM 1-HOUR IMPACTS*

1986

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	192	35.6	.71
	AS2	Cafe Area	230	40.8	.62
	AS3	T Entrance	145	29.6	.85
	AS4	T Entrance	202	36.9	.68
Congress/Atlantic	CA1	Bus Terminal	315	53.9	.47
	CA2	IFR Furniture	369	63.1	.40
	CA3	Doorway	369	63.1	.40
	CA4	Fed Res Bank	345	58.9	.43
Essex/Lincoln/ Surface	ELS1	Project Corner	48	18.9	1.33
	ELS2	Retail Shop	54	19.5	1.29
	ELS3	Parking Lot	68	20.9	1.21
Kneeland/Surface	KS1	Bus Stop	306	52.4	.48
	KS2	Parking Area	378	64.8	.39
South/Surface	SS1	Project Corner	59	20.0	1.26
	SS2	Crosswalk	68	20.9	1.21
	SS3	Artery Vent	26	16.8	1.50
	SS4	Bus Stop	43	18.4	1.37

* X = 25.24 ppm
V = 1.0 m/s
Ve = 6.1 m/s
Ae = 116 m^2
M = 4.0

TABLE C.16

DEWEY SQUARE TUNNEL NORTHBOUND VENT

INPUTS AND MAXIMUM 8-HOUR IMPACTS*

1986

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	192	46.3	.29
	AS2	Cafe Area	230	53.0	.26
	AS3	T Entrance	145	38.5	.35
	AS4	T Entrance	202	48.0	.28
Congress/Atlantic	CA1	Bus Terminal	315	70.1	.19
	CA2	IFR Furniture	369	82.0	.17
	CA3	Doorway	369	82.0	.17
	CA4	Fed Res Bank	345	76.6	.18
Essex/Lincoln/ Surface	ELS1	Project Corner	48	24.6	.26
	ELS2	Retail Shop	54	25.3	.54
	ELS3	Parking Lot	68	27.2	.50
Kneeland/Surface	KS1	Bus Stop	306	68.1	.20
	KS2	Parking Area	378	84.2	.16
South/Surface	SS1	Project Corner	59	26.0	.52
	SS2	Crosswalk	68	27.2	.50
	SS3	Artery Vent	26	21.8	.63
	SS4	Bus Stop	43	23.9	.57

* X = 13.65 ppm
V = 1.3 m/s
Ve = 6.1 m/s
Ae = 116 m^2
M = 4.0

TABLE C.17

DEWEY SQUARE TUNNEL SOUTHBOUND VENT

INPUTS AND MAXIMUM 1-HOUR IMPACTS*

1989

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	184	43.8	.69
	AS2	Cafe Area	230	51.9	.58
	AS3	T Entrance	139	36.6	.83
	AS4	T Entrance	193	45.4	.67
Congress/Atlantic	CA1	Bus Terminal	315	68.5	.44
	CA2	IFR Furniture	366	79.6	.38
	CA3	Doorway	360	78.2	.39
	CA4	Fed Res Bank	336	72.9	.42
Essex/Lincoln/ Surface	ELS1	Project Corner	48	24.0	1.27
	ELS2	Retail Shop	83	28.6	1.06
	ELS3	Parking Lot	68	26.6	1.14
Kneeland/Surface	KS1	Bus Stop	333	72.3	.42
	KS2	Parking Area	382	83.2	.36
South/Surface	SS1	Project Corner	31	22.0	1.38
	SS2	Crosswalk	48	24.0	1.27
	SS3	Artery Vent	46	23.8	1.28
	SS4	Bus Stop	26	21.4	1.42

* X = 30.39 ppm
V = 1.0 m/s
Ve = 4.8 m/s
Ae = 116 m^2
M = 4.0

TABLE C.18

DEWEY SQUARE TUNNEL SOUTHBOUND VENT

INPUTS AND MAXIMUM 8-HOUR IMPACTS*

1989

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	184	56.9	.28
	AS2	Cafe Area	230	67.5	.24
	AS3	T Entrance	139	47.6	.34
	AS4	T Entrance	193	59.0	.27
Congress/Atlantic	CA1	Bus Terminal	315	89.0	.18
	CA2	IFR Furniture	366	103.5	.16
	CA3	Doorway	360	101.7	.16
	CA4	Fed Res Bank	336	94.8	.17
Essex/Lincoln/ Surface	ELS1	Project Corner	48	31.2	.52
	ELS2	Retail Shop	83	37.2	.43
	ELS3	Parking Lot	68	34.6	.47
Kneeland/Surface	KS1	Bus Stop	333	94.0	.17
	KS2	Parking Area	382	108.2	.15
South/Surface	SS1	Project Corner	31	28.6	.57
	SS2	Crosswalk	48	31.2	.52
	SS3	Artery Vent	46	30.9	.52
	SS4	Bus Stop	26	27.8	.58

* χ = 16.18 ppm
V = 1.3 m/s
Ve = 4.8 m/s
Ae = 116 m^2
M = 4.0

TABLE C.19

DEWEY SQUARE TUNNEL NORTHBOUND VENT

INPUTS AND MAXIMUM 1-HOUR IMPACTS*

1989

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	192	35.6	.64
	AS2	Cafe Area	230	40.8	.56
	AS3	T Entrance	145	29.6	.77
	AS4	T Entrance	202	36.9	.61
Congress/Atlantic	CA1	Bus Terminal	315	53.9	.42
	CA2	IFR Furniture	369	63.1	.36
	CA3	Doorway	369	63.1	.36
	CA4	Fed Res Bank	345	58.9	.38
Essex/Lincoln/ Surface	ELS1	Project Corner	48	18.9	1.20
	ELS2	Retail Shop	54	19.5	1.16
	ELS3	Parking Lot	68	20.9	1.08
Kneeland/Surface	KS1	Bus Stop	306	52.4	.43
	KS2	Parking Area	378	64.8	.35
South/Surface	SS1	Project Corner	59	20.0	1.13
	SS2	Crosswalk	68	20.9	1.08
	SS3	Artery Vent	26	16.8	1.35
	SS4	Bus Stop	43	18.4	1.23

* X = 22.67 ppm
V = 1.0 m/s
Ve = 6.1 m/s
Ae = 116 m^2
M = 4.0

TABLE C.20

DEWEY SQUARE TUNNEL NORTHBOUND VENT

INPUTS AND MAXIMUM 8-HOUR IMPACTS*

1989

Intersection	Receptor Number	Receptor Description	S(m)	D	Xa(ppm)
Atlantic/Summer	AS1	South Station	192	46.3	.26
	AS2	Cafe Area	230	53.0	.23
	AS3	T Entrance	145	38.5	.32
	AS4	T Entrance	202	48.0	.25
Congress/Atlantic	CA1	Bus Terminal	315	70.1	.17
	CA2	IFR Furniture	369	82.0	.15
	CA3	Doorway	369	82.0	.15
	CA4	Fed Res Bank	345	76.6	.16
Essex/Lincoln/ Surface	ELS1	Project Corner	48	24.6	.49
	ELS2	Retail Shop	54	25.3	.48
	ELS3	Parking Lot	68	27.2	.45
Kneeland/Surface	KS1	Bus Stop	306	68.1	.18
	KS2	Parking Area	378	84.2	.14
South/Surface	SS1	Project Corner	59	26.0	.47
	SS2	Crosswalk	68	27.2	.45
	SS3	Artery Vent	26	21.8	.56
	SS4	Bus Stop	43	23.9	.51

* $X = 12.18$ ppm
$V = 1.3$ m/s
$Ve = 6.1$ m/s
$Ae = 116$ m^2
$M = 4.0$

MOBILE3 1986 - INTERSECTION ANALYSIS

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1): 1983
PRE-1981 MYR STRINGENCY RATE: 13%
MECHANIC TRAINING PROGRAM?: NO
FIRST MODEL YEAR COVERED: 1971
LAST MODEL YEAR COVERED: 1986
VEHICLE TYPES COVERED: LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE: IDLE
1981 & LATER MYR TEST CUTPOINTS: 1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	12.0	12.0	12.0		12.0	12.0	12.0	12.0	12.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	

COMPOSITE EMISSION FACTORS (GM/MILE)
EXHST CO: 94.38 150.27 158.42 153.60 276.51 2.39 2.85 22.35 83.54 107.20

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	14.0	14.0	14.0		14.0	14.0	14.0	14.0	14.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	

COMPOSITE EMISSION FACTORS (GM/MILE)
EXHST CO: 84.52 133.46 138.50 135.53 240.67 2.10 2.50 19.65 71.01 95.26

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	17.0	17.0	17.0		17.0	17.0	17.0	17.0	17.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	

COMPOSITE EMISSION FACTORS (GM/MILE)
EXHST CO: 72.86 113.82 115.71 114.59 198.69 1.76 2.09 16.42 58.36 81.27

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	18.0	18.0	18.0		18.0	18.0	18.0	18.0	18.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	

COMPOSITE EMISSION FACTORS (GM/MILE)
EXHST CO: 41.43 65.85 67.71 66.62 187.21 1.45 1.74 15.53 34.04 49.44

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	25.0	25.0	25.0		25.0	25.0	25.0	25.0	25.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	

COMPOSITE EMISSION FACTORS (GM/MILE)
EXHST CO: 30.16 46.98 47.15 47.05 131.28 1.03 1.23 11.03 24.50 35.48

MOBILE3 1989 - INTERSECTION ANALYSIS

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1): 1983
PRE-1981 MYR STRINGENCY RATE: 13%
MECHANIC TRAINING PROGRAM?: NO
FIRST MODEL YEAR COVERED: 1974
LAST MODEL YEAR COVERED: 1989
VEHICLE TYPES COVERED: LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE: IDLE
1981 & LATER MYR TEST CUTPOINTS: 1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	12.0	12.0	12.0		12.0	12.0	12.0	12.0	12.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	73.97	119.36	124.35	121.47	148.67	2.39	2.74	17.79	83.22	79.84

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	14.0	14.0	14.0		14.0	14.0	14.0	14.0	14.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	66.75	106.49	109.39	107.71	129.40	2.10	2.41	15.65	70.73	71.41

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	17.0	17.0	17.0		17.0	17.0	17.0	17.0	17.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	57.83	91.21	92.01	91.55	106.83	1.76	2.01	13.08	58.11	61.24

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	18.0	18.0	18.0		18.0	18.0	18.0	18.0	18.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	32.89	52.88	53.31	53.06	100.66	1.44	1.67	12.36	33.83	36.93

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	25.0	25.0	25.0		25.0	25.0	25.0	25.0	25.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	23.96	37.93	37.41	37.71	70.58	1.03	1.19	8.78	24.32	26.58

MOBILE3 1986 - INCLUDES I/M

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1971
LAST MODEL YEAR COVERED:	1986
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	168.10	278.14	313.04	292.43	481.71	3.98	4.73	37.13	212.04	195.03

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	10.0	10.0	10.0		10.0	10.0	10.0	10.0	10.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	107.03	172.01	184.49	177.12	320.49	2.74	3.26	25.60	101.88	122.52

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	15.0	15.0	15.0		15.0	15.0	15.0	15.0	15.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	80.30	126.32	130.14	127.88	225.28	1.98	2.36	18.48	66.16	90.18

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VMT MIX:	0.657	0.130	0.090		0.035	0.027	0.009	0.044	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	48.35	73.46	72.34	73.01	125.89	1.13	1.35	10.58	38.08	53.04

MOBILE3 1989 - INCLUDES I/M

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1974
LAST MODEL YEAR COVERED:	1989
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	
VMT MIX:	0.646	0.122	0.089		0.035	0.041	0.018	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	114.98	195.10	214.33	203.23	363.52	4.01	4.63	34.07	211.37	133.27

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	10.0	10.0	10.0		10.0	10.0	10.0	10.0	10.0	
VMT MIX:	0.646	0.122	0.089		0.035	0.041	0.018	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	81.40	128.91	135.86	131.85	241.86	2.77	3.19	23.49	101.50	90.88

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	15.0	15.0	15.0		15.0	15.0	15.0	15.0	15.0	
VMT MIX:	0.646	0.122	0.089		0.035	0.041	0.018	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	62.76	96.61	98.68	97.49	170.01	2.00	2.31	16.95	65.89	68.46

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VMT MIX:	0.646	0.122	0.089		0.035	0.041	0.018	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	37.65	56.28	55.54	55.97	95.01	1.14	1.32	9.71	37.85	40.26

MOBILE3 1986 - INTERSECTION ANALYSIS

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1971
LAST MODEL YEAR COVERED:	1986
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VMT MIX:	0.650	0.126	0.087		0.040	0.027	0.010	0.053	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	47.38	73.25	72.74	73.04	106.95	1.12	1.31	9.17	38.08	51.46

CAL. YEAR: 1986 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VMT MIX:	0.650	0.126	0.087		0.040	0.027	0.010	0.053	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	28.17	44.76	45.24	44.96	106.95	0.98	1.15	9.17	23.50	32.88

MOBILE3 1989 - INTERSECTION ANALYSIS

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1974
LAST MODEL YEAR COVERED:	1989
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	38.45	59.36	58.26	58.89	67.69	1.13	1.30	8.42	37.85	40.16

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	22.90	36.17	35.64	35.95	67.69	0.98	1.14	8.42	23.32	25.40

MOBILE3 1989 - GARAGE ANALYSIS

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1974
LAST MODEL YEAR COVERED:	1989
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 100.0 / 0.0 /100.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	15.0	15.0	15.0		15.0	15.0	15.0	15.0	15.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	128.78	202.59	207.05	204.47	121.12	2.81	3.23	14.71	128.09	130.97

CAL. YEAR: 1989 REGION: LOW ALTITUDE: 500. FT.
I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F)
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 0.0 / 50.0

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD.:	15.0	15.0	15.0		15.0	15.0	15.0	15.0	15.0	
VMT MIX:	0.640	0.118	0.086		0.041	0.041	0.018	0.049	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHST CO:	61.72	98.31	100.05	99.04	121.12	1.89	2.14	14.71	64.21	65.98

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection Atlantic / Sumner

Case # 1 Year 1986

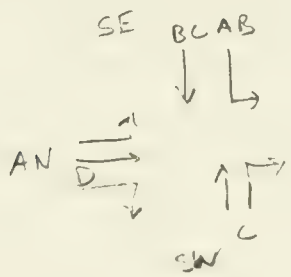
1.	Road segment or intersection approach identification	SEb	SEc	SW	AN
2.	Observed 1-hr volume (vph)	257	381	726	1159
	Observed 8-hr volume (vph)	211	312	595	950
	Projected 1-hr peak demand (vph)				
	Projected 8-hr peak demand (vph)				
3.	Percentage cold starts	50/20.6			
4.	Percentage trucks and buses	7.4			
5.	Metropolitan population				
6.	Slope				
7.	Free-flow parameters				
	Number of lanes	1	2	3	3
	Average lane width (ft)	13	13		
	Design speed (mph)	14/18			
	Highway type (see Figures 2-5)	Urban Arterial			
8.	Intersection parameters				
	Intersection designation				
	Approach width (ft)	13	26	36	48
	Percentage right turns	0	0	27	21
	Percentage left turns	100	0	0	9
	Type control and description of signal controller	Signalized			
9.	Area source parameters				
	Parking lot gate designation				
	Projected 1-hr peak entrance demand (vph)				
	Projected 1-hr peak exit demand (vph)				
	Projected 8-hr peak entrance demand (vph)				
	Projected 8-hr peak exit demand (vph)				
	Parking lot area (m^2)				
	Parking lot capacity (veh)				
	Running time required to access auxiliary parking (s)				
	Facility emptying time				
	Average cars per stall				
	Average area per stall (m^2)				

WORKSHEET B - CAPACITY ANALYSIS

Intersection Atlantic / Summer

Case # 1 Year 1986

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	SEL	SES	SW	AA
2		Free flow capacity computation:				
2.1	M_i	Number of lanes	1	2	3	3
2.2	W_f	Adjustment for lane width (Table B-1)				
2.3	T_i	Adjustment for trucks (Table B-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	AB	BC	C	D
3.2	Wa_i	Approach width with parking (ft)	21	34	36	48
3.3		Percent right turners	0	0	27	21
3.4		Percent left turners	0	0	0	9
3.5		Metropolitan area size	2.5M			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	1900	3600	3910	4750
4		Signalized intersection green phase and cycle length:	1300	2520	2730	3325
4.1	$V_{i,j}$	Demand Volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\sum_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				



OLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

ECTION: ATLANTIC AVENUE/SUMMER STREET
1 YEAR: 1986 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	SEL	SES	SW
	DEMAND VOLUME (VPH)	257.	381.	726.
	CRUISE SPEED (MPH)	14	14	14
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000
.1	NUMEBR OF LANES	1	2	3
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1330.	2520.	2730.
.4	DEMAND VOLUME (VPH)	257.	381.	726.
.5	SIGNAL CYCLE LENGTH (S)	100.		
.6	GREEN PHASE LENGTH (S)	32.	56.	39.
.7	CAPACITY (VPH)	426.	1411.	1065.
.8	PROPORTION OF VEHICLES THAT STOP	.843	.518	.831
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	6.017	5.486	16.758
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	1.52	.37	2.14
8.0	LENGTH OF QUEUE (M/LANE)	45.25	17.57	37.80
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	41.55	12.35	32.59
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.170	.170	.170
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.065	.065	.065
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.014	.013	.039
13.	LENGTH OF ACC. AND DEC. (M)	17.5	17.5	17.5
14.	LENGTH FOR EXCESS EMISSIONS (M)	45.2	35.0	37.8
15.	IDLING EMISSION RATE (G/S)	.703	.257	1.526
16.	AVERAGE EMISSION RATE (G/S-M)	.0210	.0138	.0586
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0392	-.0411	-.1090
18.	FREE-FLOW EMISSION RATE (G/S-M)	.0714	.1058	.2017

Queue length AN

$C = .29(3325)$

$\frac{6(1159-964)}{6} = 195$ m/lane

NCHPP 133 queue calculation

IF $\frac{V}{C} > 97\%$

$\frac{6 \text{ meters/car} - (\text{Volume} - \text{Capacity})}{2(\#\text{ of lanes})}$ = queue length

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: ATLANTIC AVENUE/SUMMER STREET
CASE # 1 YEAR: 1986 AVERAGING TIME: 8-HOUR

LINE 1	ROAD SEGMENT ID	SEL	SES	SW	AN
LINE 2	DEMAND VOLUME (VPH)	210.	312.	595.	950.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	1	2	3	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1900.	3600.	3900.	4750.
LINE 6.4	DEMAND VOLUME (VPH)	210.	312.	595.	950.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	80.			
LINE 6.6	GREEN PHASE LENGTH (S)	21.	41.	35.	24.
LINE 6.7	CAPACITY (VPH)	499.	1845.	1706.	1425.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.829	.534	.664	.875
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	3.869	3.701	8.776	18.472
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.73	.20	.54	2.00
LINE 8.0	LENGTH OF QUEUE (M/LANE)	27.58	11.71	18.62	40.94
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	29.71	10.81	16.06	29.55
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.009	.009	.021	.044
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.387	.159	.523	1.740
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0113	.0071	.0195	.0520
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0371	-.0391	-.0903	-.1789
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.0583	.0867	.1653	.2639

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection Atlantic / Summer

Case # 2 Year 1989

		SEL	SES	SW	ANA
1.	Road segment or intersection approach identification				
2.	Observed 1-hr volume (vph)				
	Observed 8-hr volume (vph)				
	Projected 1-hr peak demand (vph)	36	381	724	1159
	Projected 8-hr peak demand (vph)	307	312	595	950
3.	Percentage cold starts	50/20.6			
4.	Percentage trucks and buses	7.4			
5.	Metropolitan population				
6.	Slope				
7.	Free-flow parameters				
	Number of lanes	1	2	3	3
	Average lane width (ft)	13	13	12	17
	Design speed (mph)	14/18			
	Highway type (see Figures 2-5)	Urban Artery			
8.	Intersection parameters				
	Intersection designation				
	Approach width (ft)	13	26	36	50
	Percentage right turns	0	0	27	22
	Percentage left turns	10	0	0	9
	Type control and description of signal controller	Signalized			
9.	Area source parameters				
	Parking lot gate designation				
	Projected 1-hr peak entrance demand (vph)				
	Projected 1-hr peak exit demand (vph)				
	Projected 8-hr peak entrance demand (vph)				
	Projected 8-hr peak exit demand (vph)				
	Parking lot area (m^2)				
	Parking lot capacity (veh)				
	Running time required to access auxiliary parking (s)				
	Facility emptying time				
	Average cars per stall				
	Average area per stall (m^2)				

WORKSHEET 8 - CAPACITY ANALYSIS

Intersection Atlantic/Summer

Case # 2 Year 1984

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	SEL	SES	SW	AN
2		Free flow capacity computation:				
2.1	M_i	Number of lanes	1	2	3	3
2.2	W_f	Adjustment for lane width (Table 8-1)				
2.3	T_i	Adjustment for trucks (Table 8-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	AB	BC	C	D
3.2	wa_i	Approach width with parking (ft)	21	34	36	50
3.3		Percent right turners	0	0	27	22
3.4		Percent left turners	0	0	0	0
3.5		Metropolitan area size	2.5 M			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	2150	3750	3800	5350
			1505	2625	2660	3710
4		Signalized intersection green phase and cycle length:				
4.1	$V_{i,j}$	Demand volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\sum_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				

VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

SECTION: ATLANTIC AVENUE/SUMMER STREET
2 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	SEL	SES	SW
2	DEMAND VOLUME (VPH)	366.	381.	726.
4	CRUISE SPEED (MPH)	14	14	14
5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000
6.1	NUMEBR OF LANES	3	3	3
6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1505.	2625.	2660.
6.4	DEMAND VOLUME (VPH)	366.	381.	726.
6.5	SIGNAL CYCLE LENGTH (S)	100.		
6.6	GREEN PHASE LENGTH (S)	32.	56.	39.
6.7	CAPACITY (VPH)	482.	1470.	1037.
6.8	PROPORTION OF VEHICLES THAT STOP	.899	.515	.839
6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	9.135	5.447	16.920
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	3.17	.35	2.33
8.0	LENGTH OF QUEUE (M/LANE)	24.60	11.59	38.50
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	54.22	12.18	33.68
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.170	.170	.170
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.065	.065	.065
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.021	.013	.040
13.	LENGTH OF ACC. AND DEC. (M)	17.5	17.5	17.5
14.	LENGTH FOR EXCESS EMISSIONS (M)	35.0	35.0	38.5
15.	IDLING EMISSION RATE (G/S)	1.328	.252	1.582
16.	AVERAGE EMISSION RATE (G/S-M)	.0486	.0136	.0592
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0427	-.0409	-.1100
18.	FREE-FLOW EMISSION RATE (G/S-M)	.1017	.1058	.2017

Queue length AN

$C = .29(3710) = 1076$

$(1159 - 1076) = 83$ m/lane

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: ATLANTIC AVENUE/SUMMER STREET
CASE # 2 YEAR: 1989 AVERAGING TIME: 8-HOUR

LINE 1	ROAD SEGMENT ID	SEL	SES	SW	AN
LINE 2	DEMAND VOLUME (VPH)	300.	312.	595.	950.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	1	2	3	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	2150.	3750.	3800.	5300.
LINE 6.4	DEMAND VOLUME (VPH)	300.	312.	595.	950.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	80.			
LINE 6.6	GREEN PHASE LENGTH (S)	21.	41.	35.	24.
LINE 6.7	CAPACITY (VPH)	564.	1922.	1663.	1590.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.857	.532	.667	.853
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	5.714	3.687	8.818	18.005
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	1.13	.19	.56	1.48
LINE 8.0	LENGTH OF QUEUE (M/LANE)	41.09	11.64	18.75	38.98
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	32.52	10.73	16.21	27.24
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.014	.009	.021	.043
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.612	.157	.529	1.585
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0174	.0071	.0196	.0487
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0541	-.0390	-.0906	-.1763
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.0833	.0867	.1653	.2639

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection ATLANTIC/SUMMER

Case # 3 Year 1989

1.	Road segment or intersection approach identification	SEL	SES	SW	AN		
2.	Observed 1-hr volume (vph)	—	—	—	—	—	—
	Observed 8-hr volume (vph)	—	—	—	—	—	—
	Projected 1-hr peak demand (vph)	304	381	726	1159		
	Projected 8-hr peak demand (vph)	249	312	595	950		
3.	Percentage cold starts	50/20.6	—	—	—	—	—
4.	Percentage trucks and buses	7.4	—	—	—	—	—
5.	Metropolitan population	—	—	—	—	—	—
6.	Slope	—	—	—	—	—	—
7.	Free-flow parameters						
	Number of lanes	1	2	3	3		
	Average lane width (ft)	13	13	12	17		
	Design speed (mph)	14/18	—	—	—	—	—
	Highway type (see Figures 2-5)	Urban Artery					
8.	Intersection parameters						
	Intersection designation	—	—	—	—	—	—
	Approach width (ft)	13	26	36	50		
	Percentage right turns	0	0	27	22		
	Percentage left turns	100	0	0	9		
	Type control and description of signal controller	signalized					
9.	Area source parameters						
	Parking lot gate designation	—	—	—	—	—	—
	Projected 1-hr peak entrance demand (vph)	—	—	—	—	—	—
	Projected 1-hr peak exit demand (vph)	—	—	—	—	—	—
	Projected 8-hr peak entrance demand (vph)	—	—	—	—	—	—
	Projected 8-hr peak exit demand (vph)	—	—	—	—	—	—
	Parking lot area (m^2)	—					
	Parking lot capacity (veh)	—					
	Running time required to access auxiliary parking (s)	—					
	Facility emptying time	—					
	Average cars per stall	—					
	Average area per stall (m^2)	—					

WORKSHEET 8 - CAPACITY ANALYSIS

Intersection ATLANTIC/SUMMER

Case # 3 Year 1989

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	SEL	SES	SW	AN
2		Free flow capacity computation:				
2.1	M_i	Number of lanes	1	2	3	3
2.2	W_f	Adjustment for lane width (Table 8-1)				
2.3	T_i	Adjustment for trucks (Table 8-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	AB	BC	C	D
3.2	wa_i	Approach width with parking (ft)	21	34	36	50
3.3		Percent right turners	0	0	27	32
3.4		Percent left turners	0	0	0	0
3.5		Metropolitan area size	1.5 M			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	2150	3750	3600	5300
4		Signalized intersection green phase and cycle length:	1505	2625	2160	3710
4.1	$V_{i,j}$	Demand Volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\Sigma_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				

OLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

ECTION: ATLANTIC AVENUE/SUMMER STREET
3 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	SEL	SES	SW
	DEMAND VOLUME (VPH)	304.	381.	726.
	CRUISE SPEED (MPH)	14	14	14
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000
.1	NUMEBR OF LANES	3	3	3
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1505.	2625.	2660.
.4	DEMAND VOLUME (VPH)	304.	381.	726.
.5	SIGNAL CYCLE LENGTH (S)	100.		
.6	GREEN PHASE LENGTH (S)	32.	56.	39.
.7	CAPACITY (VPH)	482.	1470.	1037.
.8	PROPORTION OF VEHICLES THAT STOP	.852	.515	.839
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	7.196	5.447	16.920
.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	1.71	.35	2.33
.0	LENGTH OF QUEUE (M/LANE)	17.81	11.59	38.50
.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	41.77	12.18	33.68
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.170	.170	.170
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.065	.065	.065
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.017	.013	.040
13.	LENGTH OF ACC. AND DEC. (M)	17.5	17.5	17.5
14.	LENGTH FOR EXCESS EMISSIONS (M)	35.0	35.0	38.5
15.	IDLING EMISSION RATE (G/S)	.836	.252	1.582
16.	AVERAGE EMISSION RATE (G/S-M)	.0323	.0136	.0592
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0397	-.0409	-.1100
18.	FREE-FLOW EMISSION RATE (G/S-M)	.0844	.1058	.2017

Queue length AN

C = .29(3710) = 1076

(1159 - 1076) = 83 m/lane

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: ATLANTIC AVENUE/SUMMER STREET
CASE # 3 YEAR: 1989 AVERAGING TIME: 8-HOUR

LINE 1	ROAD SEGMENT ID	SEL	SES	SW	AN
LINE 2	DEMAND VOLUME (VPH)	249.	312.	595.	950.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	3	3	3	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	2150.	3750.	3800.	5300.
LINE 6.4	DEMAND VOLUME (VPH)	249.	312.	595.	950.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	80.			
LINE 6.6	GREEN PHASE LENGTH (S)	21.	41.	35.	24.
LINE 6.7	CAPACITY (VPH)	564.	1922.	1663.	1590.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.834	.532	.667	.853
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	4.615	3.687	8.818	18.005
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.79	.19	.56	1.48
LINE 8.0	LENGTH OF QUEUE (M/LANE)	10.81	7.76	18.75	38.98
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	29.64	10.73	16.21	27.24
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.011	.009	.021	.043
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.458	.157	.529	1.585
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0134	.0071	.0196	.0487
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0443	-.0390	-.0906	-.1763
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.0692	.0867	.1653	.2639

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection CONGRESS/ATLANTIC

Case # 1 Year 1986

		CES*	CEL*	AN*	CW*
1.	Road segment or intersection approach identification				
2.	Observed 1-hr volume (vph)	673	663	1262	640
	Observed 8-hr volume (vph)	552	544	1035	525
	Projected 1-hr peak demand (vph)				
	Projected 8-hr peak demand (vph)				
3.	Percentage cold starts (1hr/8hr)	50/20.6			
4.	Percentage trucks and buses	11.7			
5.	Metropolitan population				
6.	Slope				
7.	Free-flow parameters				
	Number of lanes	2	2	3	2
	Average lane width (ft)	12.5	13	16.7	15
	Design speed (mph)		17/25		
	Highway type (see Figures 2-5)				
8.	Intersection parameters				
	Intersection designation				
	Approach width (ft)	25	26	50	30
	Percentage right turns	C	0	7	100
	Percentage left turns	C	100	0	0
	Type control and description of signal controller				
9.	Area source parameters				
	Parking lot gate designation				
	Projected 1-hr peak entrance demand (vph)				
	Projected 1-hr peak exit demand (vph)				
	Projected 8-hr peak entrance demand (vph)				
	Projected 8-hr peak exit demand (vph)				
	Parking lot area (m^2)				
	Parking lot capacity (veh)				
	Running time required to access auxiliary parking (s)				
	Facility emptying time				
	Average cars per stall				
	Average area per stall (m^2)				

CES - Congress St EB Straight

CEL - " " " Left

AN - Atlantic Av - NB

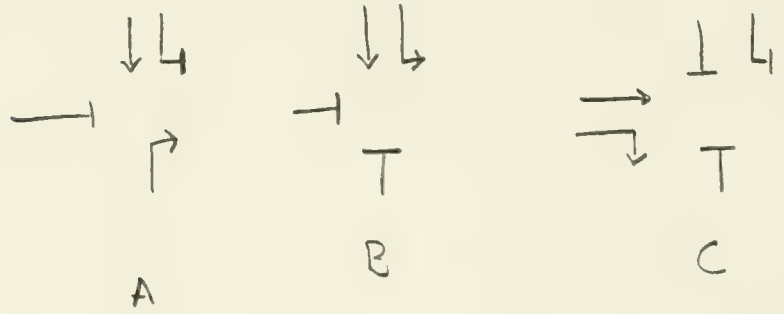
CW - Congress St WB

WORKSHEET B - CAPACITY ANALYSIS

Intersection CONGRESS / ATLANTIC

Case # 1 Year 1986

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	CEI	CEL	AN	CW
2		Free flow capacity computation:				
2.1	M_i	Number of lanes				
2.2	W_f	Adjustment for lane width (Table B-1)				
2.3	T_i	Adjustment for trucks (Table B-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	AB	B	C	A
3.2	Wa_i	Approach width with parking (ft)	33	34	50	30
3.3		Percent right turners	0	0	7	100
3.4		Percent left turners	0	0	0	0
3.5		Metropolitan area size	2.5 mil			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	3500	3800	5400	2700
4		Signalized intersection green phase and cycle length:	3150	3420	4860	2430
4.1	$V_{i,j}$	Demand Volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\Sigma_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				



VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

SECTION: CONGRESS STREET/ATLANTIC AVENUE
1 YEAR: 1986 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	CES	CEL	AN	CW
	DEMAND VOLUME (VPH)	673.	663.	1262.	640.
	CRUISE SPEED (MPH)	17	17	17	17
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
5.1	NUMEBR OF LANES	2	2	3	2
5.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3150.	3420.	4860.	2430.
5.4	DEMAND VOLUME (VPH)	673.	663.	1262.	640.
5.5	SIGNAL CYCLE LENGTH (S)	80.			
5.6	GREEN PHASE LENGTH (S)	53.	25.	27.	28.
5.7	CAPACITY (VPH)	2087.	1069.	1640.	851.
5.8	PROPORTION OF VEHICLES THAT STOP	.429	.853	.895	.882
5.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	6.419	12.565	25.096	12.550
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.48	1.63	3.34	3.04
8.0	LENGTH OF QUEUE (M/LANE)	20.68	42.60	56.87	46.77
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	6.62	28.96	31.04	35.81
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.150	.150	.150	.150
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.055	.055	.055	.055
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.016	.032	.064	.032
13.	LENGTH OF ACC. AND DEC. (M)	25.8	25.8	25.8	25.8
14.	LENGTH FOR EXCESS EMISSIONS (M)	51.7	51.7	56.9	51.7
15.	IDLING EMISSION RATE (G/S)	.153	1.196	2.461	1.464
16.	AVERAGE EMISSION RATE (G/S-M)	.0112	.0392	.0725	.0444
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0691	-.1178	-.2412	-.1125
18.	FREE-FLOW EMISSION RATE (G/S-M)	.1869	.1842	.3506	.1778

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: CONGRESS STREET/ATLANTIC AVENUE
CASE # 1 YEAR: 1986 AVERAGING TIME: 8-HOUR

LINE 1	ROAD SEGMENT ID	CES	CEL	AN	CW
LINE 2	DEMAND VOLUME (VPH)	552.	544.	1035.	525.
LINE 4	CRUISE SPEED (MPH)	25	25	25	25
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	2	2	3	2
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3500.	3800.	5400.	2700.
LINE 6.4	DEMAND VOLUME (VPH)	552.	544.	1035.	525.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	80.			
LINE 6.6	GREEN PHASE LENGTH (S)	53.	25.	27.	28.
LINE 6.7	CAPACITY (VPH)	2319.	1188.	1823.	945.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.401	.802	.820	.807
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	4.915	9.700	18.851	9.414
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.31	.85	1.31	1.25
LINE 8.0	LENGTH OF QUEUE (M/LANE)	15.68	31.64	40.33	31.99
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	5.89	24.63	24.32	25.74
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.111	.111	.111	.111
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.038	.038	.038	.038
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.009	.018	.035	.018
LINE 13.	LENGTH OF ACC. AND DEC. (M)	55.9	55.9	55.9	55.9
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	111.8	111.8	111.8	111.8
LINE 15.	IDLING EMISSION RATE (G/S)	.035	.753	1.410	.768
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0049	.0158	.0302	.0156
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0566	-.1055	-.2055	-.1020
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1533	.1511	.2875	.1458

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection CONGRESS/ATLANTIC

Case # 2 Year 1987

		CES	CEL	AN	CW
1.	Road segment or intersection approach identification				
2.	Observed 1-hr volume (vph)	—	—	—	—
	Observed 8-hr volume (vph)	—	—	—	—
	Projected 1-hr peak demand (vph)	673	948	137	640
	Projected 8-hr peak demand (vph)	552	777	124	525
3.	Percentage cold starts	50/20.4	—	—	—
4.	Percentage trucks and buses	11.7	—	—	—
5.	Metropolitan population	—	—	—	—
6.	Slope	—	—	—	—
7.	Free-flow parameters				
	Number of lanes	2	2	3	2
	Average lane width (ft)	12.5	13	16.7	15
	Design speed (mph)	—	17/25	—	—
	Highway type (see Figures 2-5)	—	—	—	—
8.	Intersection parameters				
	Intersection designation	—	—	—	—
	Approach width (ft)	25	26	50	30
	Percentage right turns	0	0	6	100
	Percentage left turns	0	100	0	0
	Type control and description of signal controller				
9.	Area source parameters				
	Parking lot gate designation	—	—	—	—
	Projected 1-hr peak entrance demand (vph)	—	—	—	—
	Projected 1-hr peak exit demand (vph)	—	—	—	—
	Projected 8-hr peak entrance demand (vph)	—	—	—	—
	Projected 8-hr peak exit demand (vph)	—	—	—	—
	Parking lot area (m^2)	—			
	Parking lot capacity (veh)	—			
	Running time required to access auxiliary parking (s)	—			
	Facility emptying time	—			
	Average cars per stall	—			
	Average area per stall (m^2)	—			

WORKSHEET B - CAPACITY ANALYSIS

Intersection CONGRESS / ATLANTIC

Case # 2 Year 1989

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	CES	CEL	AN	CW
2		Free flow capacity computation:				
2.1	M_i	Number of lanes	—	—	—	—
2.2	W_f	Adjustment for lane width (Table B-1)	—	—	—	—
2.3	T_i	Adjustment for trucks (Table B-2)	—	—	—	—
2.4	C_i	Free flow capacity	—	—	—	—
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	AB	B	C	A
3.2	wa_i	Approach width with parking (ft)	33	34	50	30
3.3		Percent right turners	0	0	6	100
3.4		Percent left turners	0	0	0	0
3.5		Metropolitan area size	2.5 mil.			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	3500	3800	5400	2700
			3150	3420	4860	2430
4		Signalized intersection green phase and cycle length:				
4.1	$V_{i,j}$	Demand volume for approach and phase	—	—	—	—
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio	—	—	—	—
4.3	approx G/Cy	Approximate G/Cy	—	—	—	—
4.4	$\sum_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase	—			
4.5	Cy	Signal cycle time (sec)	—			
4.6	Gj	Green phase length	—	—	—	—
4.7	Gj/Cy	Green phase to cycle time ratio	—	—	—	—
4.8	$C_{i,j}$	Capacity for approach i phase j	—	—	—	—
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume	—		—	
5.2	C_i	Cross street capacity	—	—	—	—
6		Four-way stop intersections:				
6.1	V_i	Approach volume	—	—	—	—
6.2	Spi	Demand split on cross streets	—		—	
6.3	C_i	Capacity of approach	—	—	—	—
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop	—	—	—	—

VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

SECTION: CONGRESS STREET/ATLANTIC AVENUE
2 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	CES	CEL	AN	CW
2	DEMAND VOLUME (VPH)	673.	948.	1371.	640.
4	CRUISE SPEED (MPH)	17	17	17	17
5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
6.1	NUMEBR OF LANES	2	2	3	2
6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3150.	3420.	4860.	2430.
6.4	DEMAND VOLUME (VPH)	673.	948.	1371.	640.
6.5	SIGNAL CYCLE LENGTH (S)	80.			
6.6	GREEN PHASE LENGTH (S)	53.	25.	27.	28.
6.7	CAPACITY (VPH)	2087.	1069.	1640.	851.
6.8	PROPORTION OF VEHICLES THAT STOP	.429	.951	.923	.882
6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	6.419	20.038	28.116	12.550
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.48	7.85	5.09	3.04
8.0	LENGTH OF QUEUE (M/LANE)	20.68	83.67	66.41	46.77
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	6.62	52.60	35.63	35.81
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.150	.150	.150	.150
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.055	.055	.055	.055
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.016	.051	.072	.032
13.	LENGTH OF ACC. AND DEC. (M)	25.8	25.8	25.8	25.8
14.	LENGTH FOR EXCESS EMISSIONS (M)	51.7	83.7	66.4	51.7
15.	IDLING EMISSION RATE (G/S)	.153	3.291	3.118	1.464
16.	AVERAGE EMISSION RATE (G/S-M)	.0112	.0552	.0750	.0444
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0691	-.1953	-.2765	-.1125
18.	FREE-FLOW EMISSION RATE (G/S-M)	.1869	.2633	.3808	.1778

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: CONGRESS STREET/ATLANTIC AVENUE
CASE # 2 YEAR: 1989 AVERAGING TIME: 8-HOUR

		CES	CEL	AN	CW
LINE 1	ROAD SEGMENT ID				
LINE 2	DEMAND VOLUME (VPH)	552.	777.	1124.	525.
LINE 4	CRUISE SPEED (MPH)	25	25	25	25
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	2	2	3	2
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3500.	3800.	5400.	2700.
LINE 6.4	DEMAND VOLUME (VPH)	552.	777.	1124.	525.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	80.			
LINE 6.6	GREEN PHASE LENGTH (S)	53.	25.	27.	28.
LINE 6.7	CAPACITY (VPH)	2319.	1188.	1823.	945.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.401	.864	.837	.807
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	4.915	14.922	20.898	9.414
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.31	1.89	1.61	1.25
LINE 8.0	LENGTH OF QUEUE (M/LANE)	15.68	50.44	45.01	31.99
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	5.89	29.50	25.35	25.74
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.111	.111	.111	.111
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.038	.038	.038	.038
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.009	.028	.039	.018
LINE 13.	LENGTH OF ACC. AND DEC. (M)	55.9	55.9	55.9	55.9
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	111.8	111.8	111.8	111.8
LINE 15.	IDLING EMISSION RATE (G/S)	.035	1.343	1.614	.768
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0049	.0259	.0339	.0156
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0566	-.1606	-.2273	-.1020
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1533	.2158	.3122	.1458

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection CONGRESS / ATLANTIC

Case # 3 Year 1979

1.	Road segment or intersection approach identification	CES	CEL	AN	CW	
2.	Observed 1-hr volume (vph)	—	—	—	—	—
	Observed 8-hr volume (vph)	—	—	—	—	—
	Projected 1-hr peak demand (vph)	673	948	1309	640	
	Projected 8-hr peak demand (vph)	552	777	1073	525	
3.	Percentage cold starts	50/20.6	—	—	—	—
4.	Percentage trucks and buses	11.7	—	—	—	—
5.	Metropolitan population	—	—	—	—	—
6.	Slope	—	—	—	—	—
7.	Free-flow parameters					
	Number of lanes	2	2	3	2	
	Average lane width (ft)	12.5	13	16.7	15	
	Design speed (mph)	—	17/25	—	—	—
	Highway type (see Figures 2-5)	—	—	—	—	—
8.	Intersection parameters					
	Intersection designation	—	—	—	—	—
	Approach width (ft)	25	26	50	30	
	Percentage right turns	0	0	7	10	
	Percentage left turns	0	10	0	0	
	Type control and description of signal controller	—	—	—	—	—
9.	Area source parameters					
	Parking lot gate designation	—	—	—	—	—
	Projected 1-hr peak entrance demand (vph)	—	—	—	—	—
	Projected 1-hr peak exit demand (vph)	—	—	—	—	—
	Projected 8-hr peak entrance demand (vph)	—	—	—	—	—
	Projected 8-hr peak exit demand (vph)	—	—	—	—	—
	Parking lot area (m^2)	—				
	Parking lot capacity (veh)	—				
	Running time required to access auxiliary parking (s)	—				
	Facility emptying time	—				
	Average cars per stall	—				
	Average area per stall (m^2)	—				

WORKSHEET 8 - CAPACITY ANALYSIS

Intersection CONGRESS / ATLANTIC

Case # 3 Year 1984

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	CES	CEL	AN	CW
2		Free flow capacity computation:				
2.1	M_i	Number of lanes				
2.2	W_p	Adjustment for lane width (Table 8-1)				
2.3	T_i	Adjustment for trucks (Table 8-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	AB	B	C	A
3.2	wa_i	Approach width with parking (ft)	33	34	50	30
3.3		Percent right turners	0	0	7	100
3.4		Percent left turners	0	0	0	0
3.5		Metropolitan area size	2.5 mil			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	3500 3150	3800 3420	5400 4860	2700 2430
4		Signalized intersection green phase and cycle length:				
4.1	$V_{i,j}$	Demand volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\Sigma_j \max(V_{i,j}Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\Sigma_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				

OLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

ECTION: CONGRESS STREET/ATLANTIC AVENUE
3 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	CES	CEL	AN	CW
	DEMAND VOLUME (VPH)	673.	948.	1309.	640.
	CRUISE SPEED (MPH)	17	17	17	17
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
.1	NUMEBR OF LANES	2	2	3	2
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3150.	3420.	4860.	2430.
.4	DEMAND VOLUME (VPH)	673.	948.	1309.	640.
.5	SIGNAL CYCLE LENGTH (S)	80.			
.6	GREEN PHASE LENGTH (S)	53.	25.	27.	28.
.7	CAPACITY (VPH)	2087.	1069.	1640.	851.
.8	PROPORTION OF VEHICLES THAT STOP	.429	.951	.907	.882
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	6.419	20.038	26.375	12.550
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.48	7.85	3.95	3.04
8.0	LENGTH OF QUEUE (M/LANE)	20.68	83.67	60.65	46.77
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	6.62	52.60	32.70	35.81
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.150	.150	.150	.150
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.055	.055	.055	.055
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.016	.051	.068	.032
13.	LENGTH OF ACC. AND DEC. (M)	25.8	25.8	25.8	25.8
14.	LENGTH FOR EXCESS EMISSIONS (M)	51.7	83.7	60.7	51.7
15.	IDLING EMISSION RATE (G/S)	.153	3.291	2.706	1.464
16.	AVERAGE EMISSION RATE (G/S-M)	.0112	.0552	.0734	.0444
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0691	-.1953	-.2563	-.1125
18.	FREE-FLOW EMISSION RATE (G/S-M)	.1869	.2633	.3636	.1778

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: CONGRESS STREET/ATLANTIC AVENUE
CASE # 3 YEAR: 1989 AVERAGING TIME: 8-HOUR

LINE 1	ROAD SEGMENT ID	CES	CEL	AN	CW
LINE 2	DEMAND VOLUME (VPH)	552.	777.	1073.	525.
LINE 4	CRUISE SPEED (MPH)	25	25	25	25
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	2	2	3	2
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3500.	3800.	5400.	2700.
LINE 6.4	DEMAND VOLUME (VPH)	552.	777.	1073.	525.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	80.			
LINE 6.6	GREEN PHASE LENGTH (S)	53.	25.	27.	28.
LINE 6.7	CAPACITY (VPH)	2319.	1188.	1823.	945.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.401	.864	.827	.807
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	4.915	14.922	19.714	9.414
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.31	1.89	1.43	1.25
LINE 8.0	LENGTH OF QUEUE (M/LANE)	15.68	50.44	42.29	31.99
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	5.89	29.50	24.74	25.74
LINE 10..	EMISSIONS FROM ACCELERATION (G/VEH-M)	.111	.111	.111	.111
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.038	.038	.038	.038
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.009	.028	.037	.018
LINE 13.	LENGTH OF ACC. AND DEC. (M)	55.9	55.9	55.9	55.9
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	111.8	111.8	111.8	111.8
LINE 15.	IDLING EMISSION RATE (G/S)	.035	1.343	1.494	.768
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0049	.0259	.0317	.0156
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0566	-.1606	-.2147	-.1020
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1533	.2158	.2981	.1458

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection ESSEX ST/LINCOLN ST/SURFACE ARTERY

Case # 1 Year 1986

1.	Road segment or intersection approach identification	EEL	EES	LN	SS	SN	
2.	Observed 1-hr volume (vph)	143	487	800	815	330	
	Observed 8-hr volume (vph)	117	399	656	668	271	
	Projected 1-hr peak demand (vph)	—	—	—	—	—	
	Projected 8-hr peak demand (vph)	—	—	—	—	—	
3.	Percentage cold starts	50/20.6	—	—	—	—	
4.	Percentage trucks and buses	7.4	—	—	—	—	
5.	Metropolitan population	—	—	—	—	—	
6.	Slope	—	—	—	—	—	
7.	Free-flow parameters						
	Number of lanes	1	3	2	4	3	
	Average lane width (ft)	16	16	16	13	11	
	Design speed (mph)	12/18	—	—	—	—	
	Highway type (see Figures 2-5)	Urban Artery					
8.	Intersection parameters						
	Intersection designation	—	—	—	—	—	
	Approach width (ft)	16	48	32	52	32	
	Percentage right turns	0	22	3	3	2	
	Percentage left turns	100	0	0	8	23	
	Type control and description of signal controller	Signalized					
9.	Area source parameters						
	Parking lot gate designation	—	—	—	—	—	
	Projected 1-hr peak entrance demand (vph)	—	—	—	—	—	
	Projected 1-hr peak exit demand (vph)	—	—	—	—	—	
	Projected 8-hr peak entrance demand (vph)	—	—	—	—	—	
	Projected 8-hr peak exit demand (vph)	—	—	—	—	—	
	Parking lot area (m^2)	—					
	Parking lot capacity (veh)	—					
	Running time required to access auxiliary parking (s)	—					
	Facility emptying time	—					
	Average cars per stall	—					
	Average area per stall (m^2)	—					

WORKSHEET B - CAPACITY ANALYSIS

Intersection ESSEX STREET/LINCOLN ST/SURFACE ARTERY

Case # 1 Year 1986

Step	Symbol	Input/Units					
1	i	Road segment (or approach) designation	EEL	EES	LN	SS	SN
2		Free flow capacity computation:					
2.1	M_i	Number of lanes					
2.2	W_p	Adjustment for lane width (Table B-1)					
2.3	T_i	Adjustment for trucks (Table B-2)					
2.4	C_i	Free flow capacity					
3		Signalized intersection capacity:					
3.1	j	Green signal phase identification	AR	C	B	A/B/C	A
3.2	wa_i	Approach width with parking (ft)	32	52	40	60	41
3.3		Percent right turners	0	22	3	3/100	2
3.4		Percent left turners	0	0	0	8	23
3.5		Metropolitan area size	2.5M				
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	2300	5500	4150	6300	380
4		Signalized intersection green phase and cycle length:	1840	4400	3320	5040	3040
4.1	$V_{i,j}$	Demand Volume for approach and phase					
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio					
4.3	approx G/Cy	Approximate G/Cy					
4.4	$\sum_j \max(V_{i,j}Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase					
4.5	Cy	Signal cycle time (sec)					
4.6	Gj	Green phase length					
4.7	Gj/Cy	Green phase to cycle time ratio					
4.8	$C_{i,j}$	Capacity for approach i phase j.					
5		Two-way stop, two-way yield or uncontrolled intersection:					
5.1	V_m+V_n	Major street two-way volume					
5.2	C_i	Cross street capacity					
6		Four-way stop intersections:					
6.1	V_i	Approach volume					
6.2	Spi	Demand split on cross streets					
6.3	C_i	Capacity of approach					
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop					

OLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

ECTION: ESSEX STREET/LINCOLN STREET/SURFACE ARTERY
1 YEAR: 1986 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	EEL	EES	LN	SS	SN
	DEMAND VOLUME (VPH)	143.	514.	800.	815.	330.
	CRUISE SPEED (MPH)	12	12	12	12	12
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000	1.0000
.1	NUMEBR OF LANES	1	3	2	4	3
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1840.	4400.	3320.	5040.	3040.
.4	DEMAND VOLUME (VPH)	143.	514.	800.	815.	330.
.5	SIGNAL CYCLE LENGTH (S)	100.				
.6	GREEN PHASE LENGTH (S)	100.	20.	36.	34.	34.
.7	CAPACITY (VPH)	1840.	880.	1195.	1714.	1034.
.8	PROPORTION OF VEHICLES THAT STOP	.000	.906	.843	.787	.740
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	.000	12.933	18.737	17.824	6.787
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.00	1.40	2.02	.91	.47
8.0	LENGTH OF QUEUE (M/LANE)	.00	28.67	62.28	28.10	14.51
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	.00	41.98	33.08	27.89	26.07
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200	.200	.200	.200
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080	.080	.080	.080
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.000	.036	.052	.050	.019
13.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9	12.9	12.9	12.9
14.	LENGTH FOR EXCESS EMISSIONS (M)	25.7	28.7	62.3	28.1	25.7
15.	IDLING EMISSION RATE (G/S)	.000	1.435	1.732	1.466	.551
16.	AVERAGE EMISSION RATE (G/S-M)	.0000	.0663	.0386	.0750	.0309
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	.0000	-.0630	-.1487	-.1032	-.0370
18.	FREE-FLOW EMISSION RATE (G/S-M)	.0397	.1428	.2222	.2264	.0917

WORKSHEET B - CAPACITY ANALYSIS

Intersection ESSEX ST/LINCOLN ST/SURFACE ARTERY

Case # 2 Year 1969

Step	Symbol	Input/Units					
1	i	Road segment (or approach) designation	EEL	EES	LN	SS	SA
2		Free flow capacity computation:					
2.1	M_i	Number of lanes					
2.2	W_p	Adjustment for lane width (Table B-1)					
2.3	T_i	Adjustment for trucks (Table B-2)					
2.4	C_i	Free flow capacity					
3		Signalized intersection capacity:					
3.1	j	Green signal phase identification	AR	C	B	A/BC	A
3.2	wa_i	Approach width with parking (ft)	22	52	40	60	41
3.3		Percent right turners	0	20	3	9/100	2
3.4		Percent left turners	0	0	0	8	23
3.5		Metropolitan area size	2.5M				
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	2300	5500	4150	6300	38
4		Signalized intersection green phase and cycle length:	1840	4400	3320	5040	30
4.1	$V_{i,j}$	Demand volume for approach and phase					
4.2	$V_{i,j}/Cs_{i,j})$	Volume to green capacity ratio					
4.3	approx G/Cy	Approximate G/Cy					
4.4	$\sum_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase					
4.5	Cy	Signal cycle time (sec)					
4.6	Gj	Green phase length					
4.7	Gj/Cy	Green phase to cycle time ratio					
4.8	$C_{i,j}$	Capacity for approach i phase j					
5		Two-way stop, two-way yield or uncontrolled intersection:					
5.1	V_m+V_n	Major street two-way volume					
5.2	C_i	Cross street capacity					
6		Four-way stop intersections:					
6.1	V_i	Approach volume					
6.2	Spi	Demand split on cross streets					
6.3	C_i	Capacity of approach					
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop					

OLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

ECTION: ESSEX STREET/LINCOLN STREET/SURFACE ARTERY
2 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	EEL	EES	LN	SS	SN
	DEMAND VOLUME (VPH)	187.	506.	1157.	876.	330.
	CRUISE SPEED (MPH)	12	12	12	12	12
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000	1.0000
.1	NUMEBR OF LANES	1	3	2	4	3
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1840.	4400.	3320.	5040.	3040.
.4	DEMAND VOLUME (VPH)	187.	506.	1157.	876.	330.
.5	SIGNAL CYCLE LENGTH (S)	100.				
.6	GREEN PHASE LENGTH (S)	100.	20.	36.	34.	34.
.7	CAPACITY (VPH)	1840.	880.	1195.	1714.	1034.
.8	PROPORTION OF VEHICLES THAT STOP	.000	.904	.982	.799	.740
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	.000	12.706	31.571	19.439	6.787
.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.00	1.35	30.29	1.05	.47
.0	LENGTH OF QUEUE (M/LANE)	.00	28.12	185.58	30.73	14.51
.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	.00	41.69	122.66	28.56	26.07
0.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200	.200	.200	.200
1.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080	.080	.080	.080
2.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.000	.036	.088	.054	.019
3.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9	12.9	12.9	12.9
4.	LENGTH FOR EXCESS EMISSIONS (M)	25.7	28.1	185.6	30.7	25.7
5.	IDLING EMISSION RATE (G/S)	.000	1.403	9.817	1.617	.551
6.	AVERAGE EMISSION RATE (G/S-M)	.0000	.0662	.0590	.0754	.0309
7.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	.0000	-.0609	-.2567	-.1190	-.0370
8.	FREE-FLOW EMISSION RATE (G/S-M)	.0519	.1406	.3214	.2433	.0917

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: ESSEX STREET/LINCOLN STREET/SURFACE ARTERY
CASE # 2 YEAR: 1989 AVERAGING TIME: 8-HOUR

		EEL	EES	LN	SS	SN
LINE 1	ROAD SEGMENT ID					
LINE 2	DEMAND VOLUME (VPH)	153.	415.	949.	718.	271.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	1	3	2	4	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	2300.	5500.	4150.	6300.	3800.
LINE 6.4	DEMAND VOLUME (VPH)	153.	415.	949.	718.	271.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.				
LINE 6.6	GREEN PHASE LENGTH (S)	100.	20.	36.	44.	44.
LINE 6.7	CAPACITY (VPH)	2300.	1100.	1494.	2772.	1672.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.000	.865	.830	.632	.603
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	.000	9.975	21.873	12.606	4.539
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.00	.61	1.74	.35	.19
LINE 8.0	LENGTH OF QUEUE (M/LANE)	.00	21.16	70.84	19.43	9.47
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	.00	36.59	30.75	18.15	17.30
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.000	.019	.042	.024	.009
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	70.8	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.000	.966	1.818	.737	.262
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0000	.0262	.0427	.0247	.0088
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	.0000	-.0736	-.1761	-.1014	-.0366
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.0425	.1153	.2636	.1994	.0753

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection ESSEX ST / LINCOLN ST / SURFACE ARTERY

Case # 3 Year 1989

		EEL	EES	LN	SS	SN
1.	Road segment or intersection approach identification					
2.	Observed 1-hr volume (vph)	—	—	—	—	—
	Observed 8-hr volume (vph)	—	—	—	—	—
	Projected 1-hr peak demand (vph)	167	526	1020	815	330
	Projected 8-hr peak demand (vph)	137	115	836	668	271
3.	Percentage cold starts	50/20.6	—	—	—	—
4.	Percentage trucks and buses	7.4	—	—	—	—
5.	Metropolitan population	—	—	—	—	—
6.	Slope	—	—	—	—	—
7.	Free-flow parameters					
	Number of lanes	1	3	2	4	3
	Average lane width (ft)	16	16	14	13	11
	Design speed (mph)	12/18	—	—	—	—
	Highway type (see Figures 2-5)	—	Urban Art			—
8.	Intersection parameters					
	Intersection designation	—	—	—	—	—
	Approach width (ft)	16	48	32	52	33
	Percentage right turns	0	21	4	3	2
	Percentage left turns	100	0	0	8	23
	Type control and description of signal controller					
9.	Area source parameters					
	Parking lot gate designation	—	—	—	—	—
	Projected 1-hr peak entrance demand (vph)	—	—	—	—	—
	Projected 1-hr peak exit demand (vph)	—	—	—	—	—
	Projected 8-hr peak entrance demand (vph)	—	—	—	—	—
	Projected 8-hr peak exit demand (vph)	—	—	—	—	—
	Parking lot area (m^2)	—				
	Parking lot capacity (veh)	—				
	Running time required to access auxiliary parking (s)	—				
	Facility emptying time	—				
	Average cars per stall	—				
	Average area per stall (m^2)	—				

WORKSHEET B - CAPACITY ANALYSIS

Intersection ESSEX ST/LINCOLN ST/SURFACE ARTERY

Case # 3 Year 1989

Step	Symbol	Input/Units					
1	i	Road segment (or approach) designation	EEL	EES	LN	SS	SN
2		Free flow capacity computation:					
2.1	M_i	Number of lanes					
2.2	W_p	Adjustment for lane width (Table B-1)					
2.3	T_i	Adjustment for trucks (Table B-2)					
2.4	C_i	Free flow capacity					
3		Signalized intersection capacity:					
3.1	j	Green signal phase identification	AB	C	B	A/BC	A
3.2	wa_i	Approach width with parking (ft)	22	52	40	60	41
3.3		Percent right turners	0	21	4	3/100	2
3.4		Percent left turners	0	0	0	8	23
3.5		Metropolitan area size	2.5M				
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	2300	5300	4150	6300	38
			1840	4400	3320	3320	30
4		Signalized intersection green phase and cycle length:					
4.1	$V_{i,j}$	Demand volume for approach and phase					
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio					
4.3	approx G/Cy	Approximate G/Cy					
4.4	$\sum_j \max(V_{i,j}Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase					
4.5	Cy	Signal cycle time (sec)					
4.6	Gj	Green phase length					
4.7	Gj/Cy	Green phase to cycle time ratio					
4.8	$C_{i,j}$	Capacity for approach i phase j					
5		Two-way stop, two-way yield or uncontrolled intersection:					
5.1	V_m+V_n	Major street two-way volume					
5.2	C_i	Cross street capacity					
6		Four-way stop intersections:					
6.1	V_i	Approach volume					
6.2	Spi	Demand split on cross streets					
6.3	C_i	Capacity of approach					
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop					

VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

JURISDICTION: ESSEX STREET/LINCOLN STREET/SURFACE ARTERY
RUN 3 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	EEL	EES	LN	SS	SN
1.	DEMAND VOLUME (VPH)	167.	506.	1020.	815.	330.
2.	CRUISE SPEED (MPH)	12	12	12	12	12
3.	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000	1.0000
4.1	NUMEBR OF LANES	1	3	2	4	3
4.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1840.	4400.	3320.	5040.	3040.
4.4	DEMAND VOLUME (VPH)	167.	506.	1020.	815.	330.
4.5	SIGNAL CYCLE LENGTH (S)	100.				
4.6	GREEN PHASE LENGTH (S)	100.	20.	36.	34.	34.
4.7	CAPACITY (VPH)	1840.	880.	1195.	1714.	1034.
4.8	PROPORTION OF VEHICLES THAT STOP	.000	.904	.924	.787	.740
4.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	.000	12.706	26.175	17.824	6.787
5.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.00	1.35	5.82	.91	.47
6.0	LENGTH OF QUEUE (M/LANE)	.00	28.12	95.99	28.10	14.51
7.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	.00	41.69	47.10	27.89	26.07
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200	.200	.200	.200
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080	.080	.080	.080
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.000	.036	.073	.050	.019
13.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9	12.9	12.9	12.9
14.	LENGTH FOR EXCESS EMISSIONS (M)	25.7	28.1	96.0	28.1	25.7
15.	IDLING EMISSION RATE (G/S)	.000	1.403	3.217	1.466	.551
16.	AVERAGE EMISSION RATE (G/S-M)	.0000	.0662	.0433	.0750	.0309
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	.0000	-.0609	-.2184	-.1032	-.0370
18.	FREE-FLOW EMISSION RATE (G/S-M)	.0464	.1406	.2833	.2264	.0917

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: ESSEX STREET/LINCOLN STREET/SURFACE ARTERY
CASE # 3 YEAR: 1989 AVERAGING TIME: 8-HOUR

LINE 1	ROAD SEGMENT ID	EEL	EES	LN	SS	SN
LINE 2	DEMAND VOLUME (VPH)	137.	415.	836.	668.	271.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	1	3	2	4	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	2300.	5500.	4150.	6300.	3800.
LINE 6.4	DEMAND VOLUME (VPH)	137.	415.	836.	668.	271.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.				
LINE 6.6	GREEN PHASE LENGTH (S)	100.	20.	36.	44.	44.
LINE 6.7	CAPACITY (VPH)	2300.	1100.	1494.	2772.	1672.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.000	.865	.801	.626	.603
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	.000	9.975	18.611	11.624	4.539
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.00	.61	1.27	.32	.19
LINE 8.0	LENGTH OF QUEUE (M/LANE)	.00	21.16	59.65	17.91	9.47
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	.00	36.59	28.71	17.95	17.30
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.000	.019	.035	.022	.009
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	59.6	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.000	.966	1.481	.676	.262
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0000	.0262	.0420	.0227	.0088
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	.0000	-.0736	-.1441	-.0935	-.0366
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.0381	.1153	.2322	.1856	.0753

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection KNEELAND / SURFACE ARTERY

Case # 1 Year 2_

1.	Road segment or intersection approach identification	KE	KW	SS			
2.	Observed 1-hr volume (vph)	841	29	1874			
	Observed 8-hr volume (vph)	695	452	1567			
	Projected 1-hr peak demand (vph)						
	Projected 8-hr peak demand (vph)						
3.	Percentage cold starts (1hr/8hr)	50/20.6					
4.	Percentage trucks and buses	7.4					
5.	Metropolitan population						
6.	Slope						
7.	Free-flow parameters						
	Number of lanes	3	2	4			
	Average lane width (ft)	11	10	9			
	Design speed (mph)	12/18					
	Highway type (see Figures 2-5)		Urban Arterial				
8.	Intersection parameters						
	Intersection designation						
	Approach width (ft)	33	20	36			
	Percentage right turns	38	3	18			
	Percentage left turns	43	53	4			
	Type control and description of signal controller		Signalized				
9.	Area source parameters						
	Parking lot gate designation						
	Projected 1-hr peak entrance demand (vph)						
	Projected 1-hr peak exit demand (vph)						
	Projected 8-hr peak entrance demand (vph)						
	Projected 8-hr peak exit demand (vph)						
	Parking lot area (m^2)						
	Parking lot capacity (veh)						
	Running time required to access auxiliary parking (s)						
	Facility emptying time						
	Average cars per stall						
	Average area per stall (m^2)						

WORKSHEET B - CAPACITY ANALYSIS

Intersection KNEFLAND / SURFACE ARTERIAL

Case # 1 Year 86

Step	Symbol	Input/Units					
1	i	Road segment (or approach) designation			SS		
2		Free flow capacity computation:					
2.1	M_i	Number of lanes					
2.2	W_f	Adjustment for lane width (Table B-1)					
2.3	T_i	Adjustment for trucks (Table B-2)					
2.4	C_i	Free flow capacity					
3		Signalized intersection capacity:					
3.1	j	Green signal phase identification	B	C	D	D	AR
3.2	Wa_i	Approach width with parking (ft)	19	41	41	38	44
3.3		Percent right turners	100	38	38	3	18
3.4		Percent left turners	0	0	43	53	0
3.5		Metropolitan area size	2.5 mil				
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	465	1200/340			1650
4		Signalized intersection green phase and cycle length:					
4.1	$V_{i,j}$	Demand Volume for approach and phase					
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio					
4.3	approx G/Cy	Approximate G/Cy					
4.4	$\Sigma_j \max(V_{i,j}Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase					
4.5	Cy	Signal cycle time (sec)					
4.6	Gj	Green phase length					
4.7	Gj/Cy	Green phase to cycle time ratio					
4.8	$C_{i,j}$	Capacity for approach i phase j					
5		Two-way stop, two-way yield or uncontrolled intersection:					
5.1	V_m+V_n	Major street two-way volume					
5.2	C_i	Cross street capacity					
6		Four-way stop intersections:					
6.1	V_i	Approach volume					
6.2	Spi	Demand split on cross streets					
6.3	C_i	Capacity of approach					
7	C_i	Approach capacity $\Sigma_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop					

(REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

KNEELAND STREET/SURFACE ARTERY
: 1986 AVERAGING TIME: 1-HOUR

D SEGMENT ID	KE	KW
IAND VOLUME (VPH)	848.	564.
IISE SPEED (MPH)	12	12
EE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000
MEBR OF LANES	3	3
PACITY SERVICE VOLUME (VPH OF GREEN)	1336.	2592.
PACITY SERVICE VOLUME (VPH OF GREEN)	3402.	0.
PACITY SERVICE VOLUME (VPH OF GREEN)	2916.	0.
MAND VOLUME (VPH)	326.	564.
MAND VOLUME (VPH)	113.	0.
MAND VOLUME (VPH)	409.	0.
GNAL CYCLE LENGTH (S)	100.	
EEN PHASE LENGTH (S)	83.	36.
EEN PHASE LENGTH (S)	15.	0.
EEN PHASE LENGTH (S)	36.	0.
APACITY (VPH)	2669.	933.
ROPORTION OF VEHICLES THAT STOP	.225	.818
ROPORTION OF VEHICLES THAT STOP	.879	.000
ROPORTION OF VEHICLES THAT STOP	.744	.000
UMBER OF VEHICLES THAT STOP PER CYCLE	2.036	12.815
UMBER OF VEHICLES THAT STOP PER CYCLE	2.760	.000
UMBER OF VEHICLES THAT STOP PER CYCLE	8.457	.000
VERAGE NUMBER OF VEHICLES IN QUEUE	.47	1.53
ENGTH OF QUEUE (M/LANE)	27.44	28.69
VERAGE EXCESS RUNNING TIME (S/VEH)	17.83	32.07
EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200
EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080
EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.037	.036
LENGTH OF ACC. AND DEC. (M)	12.9	12.9
LENGTH FOR EXCESS EMISSIONS (M)	27.4	28.7
IDLING EMISSION RATE (G/S)	.923	1.181
AVERAGE EMISSION RATE (G/S-M)	.0511	.0573
ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0815	-.0709
FREE-FLOW EMISSION RATE (G/S-M)	.2356	.1567

Queue length SS

$C = .46(3766) = 1732$

$\frac{6(1874-1732)}{8} = 106$ m/lane

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: KNEELAND STREET/SURFACE ARTERY
CASE # 1 YEAR: 1986 AVERAGING TIME: 8-HOUR

		KE	KW	SS
LINE 1	ROAD SEGMENT ID			
LINE 2	DEMAND VOLUME (VPH)	695.	462.	1367.
LINE 4	CRUISE SPEED (MPH)	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	3	3	4
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1650.	3200.	4650.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	4200.	0.	0.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3600.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	267.	462.	1367.
LINE 6.4	DEMAND VOLUME (VPH)	126.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	302.	0.	0.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.		
LINE 6.6	GREEN PHASE LENGTH (S)	83.	36.	46.
LINE 6.6	GREEN PHASE LENGTH (S)	15.	0.	0.
LINE 6.6	GREEN PHASE LENGTH (S)	36.	0.	0.
LINE 6.7	CAPACITY (VPH)	3296.	1152.	2139.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.203	.748	.765
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.876	.000	.000
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.699	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	1.504	9.599	29.043
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	3.067	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	5.861	.000	.000
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.27	.67	1.77
LINE 8.0	LENGTH OF QUEUE (M/LANE)	21.40	20.54	46.22
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	17.42	26.03	23.63
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.020	.018	.055
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.678	.731	1.932
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0216	.0217	.0609
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0827	-.0743	-.2295
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1931	.1283	.3797

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection KIRKLAND/CLEARY ARTERIAL

Case # 2 Year 1989

1.	Road segment or intersection approach identification	KE	KW	ST			
2.	Observed 1-hr volume (vph)						
	Observed 8-hr volume (vph)						
	Projected 1-hr peak demand (vph)	[illegible]	514	232			
	Projected 8-hr peak demand (vph)	[illegible]	420	190			
3.	Percentage cold starts	50	20.6				
4.	Percentage trucks and buses	7.4					
5.	Metropolitan population						
6.	Slope						
7.	Free-flow parameters						
	Number of lanes	3	3	2			
	Average lane width (ft)	11	11	12			
	Design speed (mph)	25	25				
	Highway type (see Figures 2-5)		1	1			
8.	Intersection parameters						
	Intersection designation						
	Approach width (ft)	23	30	23			
	Percentage right turns	28	3	15			
	Percentage left turns	43	51	3			
	Type control and description of signal controller	1		1			
9.	Area source parameters						
	Parking lot gate designation						
	Projected 1-hr peak entrance demand (vph)						
	Projected 1-hr peak exit demand (vph)						
	Projected 8-hr peak entrance demand (vph)						
	Projected 8-hr peak exit demand (vph)						
	Parking lot area (m^2)						
	Parking lot capacity (veh)						
	Running time required to access auxiliary parking (s)						
	Facility emptying time						
	Average cars per stall						
	Average area per stall (m^2)						

WORKSHEET B - CAPACITY ANALYSIS

Intersection KNEELAND / SURFACE ARTLRY

Case # 2 Year 1989

Step	Symbol	Input/Units	
1	i	Road segment (or approach) designation	KE KW
2		Free flow capacity computation:	
2.1	M_i	Number of lanes	
2.2	w_f	Adjustment for lane width (Table B-1)	
2.3	T_i	Adjustment for trucks (Table B-2)	
2.4	C_i	Free flow capacity	
3		Signalized intersection capacity:	
3.1	j	Green signal phase identification	PK/D L AB
3.2	wa_i	Approach width with parking (ft)	19 41 41 32 44
3.3		Percent right turners	12/32/32 12 15
3.4		Percent left turners	illegible
3.5		Metropolitan area size	illegible
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	1454 4262 2107 4650
4		Signalized intersection green phase and cycle length:	1336 3442/2916 2592 3766
4.1	$V_{i,j}$	Demand Volume for approach and phase	
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio	
4.3	approx G/Cy	Approximate G/Cy	
4.4	$\sum_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase	
4.5	Cy	Signal cycle time (sec)	
4.6	Gj	Green phase length	
4.7	Gj/Cy	Green phase to cycle time ratio	
4.8	$C_{i,j}$	Capacity for approach i phase j	
5		Two-way stop, two-way yield or uncontrolled intersection:	
5.1	V_m+V_n	Major street two-way volume	
5.2	C_i	Cross street capacity	
6		Four-way stop intersections:	
6.1	V_i	Approach volume	
6.2	Spi	Demand split on cross streets	
6.3	C_i	Capacity of approach	
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop	

LUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

ECTION: KNEELAND STREET/SURFACE ARTERY
2 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	KE	KW
	DEMAND VOLUME (VPH)	848.	564.
	CRUISE SPEED (MPH)	12	12
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000
.1	NUMEBR OF LANES	3	3
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1336.	2592.
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3442.	0.
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	2916.	0.
.4	DEMAND VOLUME (VPH)	326.	564.
.4	DEMAND VOLUME (VPH)	113.	0.
.4	DEMAND VOLUME (VPH)	409.	0.
.5	SIGNAL CYCLE LENGTH (S)	100.	
.6	GREEN PHASE LENGTH (S)	83.	36.
.6	GREEN PHASE LENGTH (S)	15.	0.
.6	GREEN PHASE LENGTH (S)	36.	0.
.7	CAPACITY (VPH)	2675.	933.
.8	PROPORTION OF VEHICLES THAT STOP	.225	.818
.8	PROPORTION OF VEHICLES THAT STOP	.879	.000
.8	PROPORTION OF VEHICLES THAT STOP	.744	.000
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.036	12.815
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.759	.000
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	8.457	.000
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.46	1.53
8.0	LENGTH OF QUEUE (M/LANE)	27.43	28.69
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	17.83	32.07
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.037	.036
13.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9
14.	LENGTH FOR EXCESS EMISSIONS (M)	27.4	28.7
15.	IDLING EMISSION RATE (G/S)	.923	1.181
16.	AVERAGE EMISSION RATE (G/S-M)	.0511	.0573
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0815	-.0709
18.	FREE-FLOW EMISSION RATE (G/S-M)	.2356	.1567

Queue length SS

$C = .46(3766) = 1732$

$\frac{6(2327-1732)}{6} = 446$ m/lane

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: KNEELAND STREET/SURFACE ARTERY
CASE # 2 YEAR: 1989 AVERAGING TIME: 8-HOUR

		KE	KW	SS
LINE 1	ROAD SEGMENT ID			
LINE 2	DEMAND VOLUME (VPH)	695.	462.	1908.
LINE 4	CRUISE SPEED (MPH)	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	3	3	4
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1650.	3200.	4650.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	4250.	0.	0.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3600.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	267.	462.	1908.
LINE 6.4	DEMAND VOLUME (VPH)	126.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	302.	0.	0.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.		
LINE 6.6	GREEN PHASE LENGTH (S)	83.	36.	46.
LINE 6.6	GREEN PHASE LENGTH (S)	15.	0.	0.
LINE 6.6	GREEN PHASE LENGTH (S)	36.	0.	0.
LINE 6.7	CAPACITY (VPH)	3303.	1152.	2139.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.203	.748	.916
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.876	.000	.000
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.699	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	1.504	9.599	48.535
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	3.066	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	5.861	.000	.000
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.27	.67	8.26
LINE 8.0	LENGTH OF QUEUE (M/LANE)	21.39	20.54	85.19
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	17.42	26.03	38.63
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.020	.018	.092
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	85.2
LINE 15.	IDLING EMISSION RATE (G/S)	.677	.731	4.715
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0216	.0217	.0867
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0827	-.0743	-.3986
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1931	.1283	.5300

VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

SECTION: KNEELAND STREET/SURFACE ARTERY MIT
2 YEAR: 1989 AVERAGING TIME: 1-HOUR

1	ROAD SEGMENT ID	KE
2	DEMAND VOLUME (VPH)	848.
4	CRUISE SPEED (MPH)	12
5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000
6.1	NUMEBR OF LANES	3
6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1336.
6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3442.
6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	2916.
6.4	DEMAND VOLUME (VPH)	326.
6.4	DEMAND VOLUME (VPH)	113.
6.4	DEMAND VOLUME (VPH)	409.
6.5	SIGNAL CYCLE LENGTH (S)	100.
6.6	GREEN PHASE LENGTH (S)	69.
6.6	GREEN PHASE LENGTH (S)	10.
6.6	GREEN PHASE LENGTH (S)	20.
6.7	CAPACITY (VPH)	1849.
6.8	PROPORTION OF VEHICLES THAT STOP	.410
6.8	PROPORTION OF VEHICLES THAT STOP	.931
6.8	PROPORTION OF VEHICLES THAT STOP	.931
6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	3.713
6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.921
6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	10.572
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.85
8.0	LENGTH OF QUEUE (M/LANE)	36.11
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	27.62
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.048
13.	LENGTH OF ACC. AND DEC. (M)	12.9
14.	LENGTH FOR EXCESS EMISSIONS (M)	36.1
15.	IDLING EMISSION RATE (G/S)	1.509
16.	AVERAGE EMISSION RATE (G/S-M)	.0590
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.1131
18.	FREE-FLOW EMISSION RATE (G/S-M)	.2356

Queue length KW

$C = .20(2592) = 518$

$\frac{6(564 - 518)}{6} = 46 \text{ m/lane}$

Queue length SS

$C = .58(3766) = 2184$

$\frac{6(2327 - 2184)}{8} = 107 \text{ m/lane}$

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: KNEELAND STREET/SURFACE ARTERY MIT
CASE # 2 YEAR: 1989 AVERAGING TIME: 8-HOUR

		KE	KW	SS
LINE 1	ROAD SEGMENT ID			
LINE 2	DEMAND VOLUME (VPH)	695.	462.	1908.
LINE 4	CRUISE SPEED (MPH)	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	3	3	4
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1650.	3200.	4650.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	4250.	0.	0.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3600.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	267.	462.	1908.
LINE 6.4	DEMAND VOLUME (VPH)	126.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	302.	0.	0.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.		
LINE 6.6	GREEN PHASE LENGTH (S)	78.	20.	62.
LINE 6.6	GREEN PHASE LENGTH (S)	15.	0.	0.
LINE 6.6	GREEN PHASE LENGTH (S)	20.	0.	0.
LINE 6.7	CAPACITY (VPH)	2645.	640.	2883.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.262	.935	.644
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.876	.000	.000
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.873	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	1.947	11.999	34.154
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	3.066	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	7.326	.000	.000
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.36	2.60	1.96
LINE 8.0	LENGTH OF QUEUE (M/LANE)	25.39	29.19	54.17
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	23.52	52.00	14.69
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.023	.023	.065
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.977	1.578	1.493
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0286	.0386	.0582
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0948	-.0814	-.2833
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1931	.1283	.5300

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection KNEELAND / SURFACE ARTERY

Case # 3 Year 1989

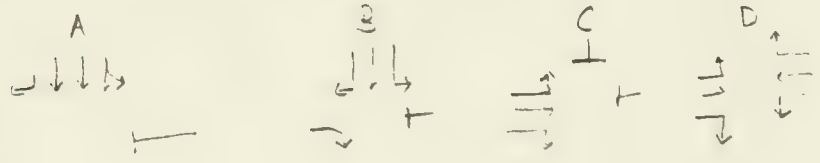
1.	Road segment or intersection approach identification	KE	KW	SS			
2.	Observed 1-hr volume (vph)	848	5[illegible]	2187			
	Observed 8-hr volume (vph)	695	423	1793			
	Projected 1-hr peak demand (vph)						
	Projected 8-hr peak demand (vph)						
3.	Percentage cold starts	50/30.6					
4.	Percentage trucks and buses	7.4					
5.	Metropolitan population						
6.	Slope						
7.	Free-flow parameters						
	Number of lanes	2	3	4			
	Average lane width (ft)	18	10	12			
	Design speed (mph)	12/18					
	Highway type (see Figures 2-5)	Urban Arterial					
8.	Intersection parameters						
	Intersection designation						
	Approach width (ft)	36	30	48			
	Percentage right turns	38	3	11			
	Percentage left turns	43	54	3			
	Type control and description of signal controller	signalized					
9.	Area source parameters						
	Parking lot gate designation						
	Projected 1-hr peak entrance demand (vph)						
	Projected 1-hr peak exit demand (vph)						
	Projected 8-hr peak entrance demand (vph)						
	Projected 8-hr peak exit demand (vph)						
	Parking lot area (m^2)						
	Parking lot capacity (veh)						
	Running time required to access auxiliary parking (s)						
	Facility emptying time						
	Average cars per stall						
	Average area per stall (m^2)						

WORKSHEET B - CAPACITY ANALYSIS

Intersection KNEELAND/SURFACE ARTERY

Case # 3 Year 1989

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	KE	KW	SE	
2		Free flow capacity computation:				
2.1	M_i	Number of lanes				
2.2	W_f	Adjustment for lane width (Table B-1)				
2.3	T_i	Adjustment for trucks (Table B-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	B/C/D	D	AB	
3.2	wa_i	Approach width with parking (ft)	19/41/41	38	44	
3.3		Percent right turners	100/36/38	3	16	
3.4		Percent left turners	0/43	54	0	
3.5		Metropolitan area size	2.5 mil			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	1650/1320/1800	1320	1650	
4		Signalized intersection green phase and cycle length:	1320/1320/1296		3766	
4.1	$V_{i,j}$	Demand Volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\Sigma_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\Sigma_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				



VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

SECTION: KNEELAND STREET/SURFACE ARTERY
3 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	KE	KW
E1			
E2	DEMAND VOLUME (VPH)	848.	564.
E4	CRUISE SPEED (MPH)	12	12
E5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000
E 6.1	NUMEBR OF LANES	3	3
E 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1336.	2592.
E 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3442.	0.
E 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	2916.	0.
E 6.4	DEMAND VOLUME (VPH)	326.	564.
E 6.4	DEMAND VOLUME (VPH)	113.	0.
E 6.4	DEMAND VOLUME (VPH)	409.	0.
E 6.5	SIGNAL CYCLE LENGTH (S)	100.	
E 6.6	GREEN PHASE LENGTH (S)	83.	36.
E 6.6	GREEN PHASE LENGTH (S)	15.	0.
E 6.6	GREEN PHASE LENGTH (S)	36.	0.
E 6.7	CAPACITY (VPH)	2675.	933.
E 6.8	PROPORTION OF VEHICLES THAT STOP	.225	.818
E 6.8	PROPORTION OF VEHICLES THAT STOP	.879	.000
E 6.8	PROPORTION OF VEHICLES THAT STOP	.744	.000
E 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.036	12.815
E 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.759	.000
E 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	8.457	.000
E 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.46	1.53
E 8.0	LENGTH OF QUEUE (M/LANE)	27.43	28.69
E 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	17.83	32.07
E 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200
E 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080
E 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.037	.036
E 13.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9
E 14.	LENGTH FOR EXCESS EMISSIONS (M)	27.4	28.7
E 15.	IDLING EMISSION RATE (G/S)	.923	1.181
E 16.	AVERAGE EMISSION RATE (G/S-M)	.0511	.0573
E 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0815	-.0709
E 18.	FREE-FLOW EMISSION RATE (G/S-M)	.2356	.1567

Queue length SS

$C = .46(3766) = 1732$

$\frac{6(2187 - 1732)}{2} = 341.$ m/lane

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: KNEELAND STREET/SURFACE ARTERY
CASE # 3 YEAR: 1989 AVERAGING TIME: 8-HOUR

		KE	KW	SS
LINE 1	ROAD SEGMENT ID			
LINE 2	DEMAND VOLUME (VPH)	695.	462.	1793.
LINE 4	CRUISE SPEED (MPH)	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	3	3	4
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1650.	3200.	4650.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	4250.	0.	0.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	3600.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	267.	462.	1793.
LINE 6.4	DEMAND VOLUME (VPH)	126.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	302.	0.	0.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.		
LINE 6.6	GREEN PHASE LENGTH (S)	83.	36.	46.
LINE 6.6	GREEN PHASE LENGTH (S)	15.	0.	0.
LINE 6.6	GREEN PHASE LENGTH (S)	36.	0.	0.
LINE 6.7	CAPACITY (VPH)	3303.	1152.	2139.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.203	.748	.879
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.876	.000	.000
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.699	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	1.504	9.599	43.774
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	3.066	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	5.861	.000	.000
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.27	.67	5.18
LINE 8.0	LENGTH OF QUEUE (M/LANE)	21.39	20.54	73.43
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	17.42	26.03	32.45
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.020	.018	.083
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	73.4
LINE 15.	IDLING EMISSION RATE (G/S)	.677	.731	3.650
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0216	.0217	.0825
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0827	-.0743	-.3552
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1931	.1283	.4981

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection Surface Artery / South St

Case # 1 Year 1986

1.	Road segment or intersection approach identification	SAN*	SAS*	SN*	SS*		
2.	Observed 1-hr volume (vph)	760	906	360	243		
	Observed 8-hr volume (vph)	623	743	295	199		
	Projected 1-hr peak demand (vph)	—	—	—	—	—	—
	Projected 8-hr peak demand (vph)	—	—	—	—	—	—
3.	Percentage cold starts	50/20.5	—	—	—	—	—
4.	Percentage trucks and buses	7.4	—	—	—	—	—
5.	Metropolitan population	—	—	—	—	—	—
6.	Slope	—	—	—	—	—	—
7.	Free-flow parameters						
	Number of lanes	4	3	3	3		
	Average lane width (ft)	13.7	11	14	10.6		
	Design speed (mph)	12/	—	—	—	—	—
	Highway type (see Figures 2-5)	—	Urban Arterial				—
8.	Intersection parameters						
	Intersection designation	—	—	—	—	—	—
	Approach width (ft)	55	32	42	32		
	Percentage right turns	63	0	52	100		
	Percentage left turns	16	1	27	0		
	Type control and description of signal controller	Signalized					
9.	Area source parameters						
	Parking lot gate designation	—	—	—	—	—	—
	Projected 1-hr peak entrance demand (vph)	—	—	—	—	—	—
	Projected 1-hr peak exit demand (vph)	—	—	—	—	—	—
	Projected 8-hr peak entrance demand (vph)	—	—	—	—	—	—
	Projected 8-hr peak exit demand (vph)	—	—	—	—	—	—
	Parking lot area (m^2)	—					
	Parking lot capacity (veh)	—					
	Running time required to access auxiliary parking (s)	—					
	Facility emptying time	—					
	Average cars per stall	—					
	Average area per stall (m^2)	—					

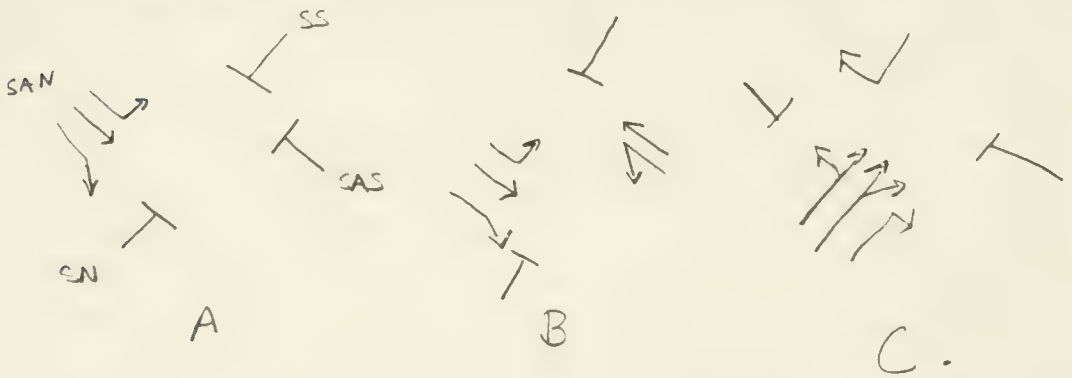
* SAE — Surface Artery North
SAW — Surface Artery South
SN — South Street North
SS — South Street South

WORKSHEET B - CAPACITY ANALYSIS

Intersection Surface Artery / South Street

Case # 1 Year 1986

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	SAN	SAS	SN	SS
2		Free flow capacity computation:				
2.1	M_i	Number of lanes				
2.2	W_f	Adjustment for lane width (Table B-1)				
2.3	T_i	Adjustment for trucks (Table B-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	A/B	B	C	C
3.2	Wa_i	Approach width with parking (ft)	19/63	41	50	40
3.3		Percent right turners	3/63	0	52	100
3.4		Percent left turners	7/16	1	37	0
3.5		Metropolitan area size	2.5 mil.			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	1900/520	1900/[illegible]	4200/[illegible]	4450/[illegible]
4		Signalized intersection green phase and cycle length:				
4.1	$V_{i,j}$	Demand Volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\Sigma_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_I	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				



LUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

CTION: SURFACE ARTERY/SOUTH STREET
1 YEAR: 1986 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	SAN	SAS	SN	SS
	DEMAND VOLUME (VPH)	760.	906.	360.	243.
	CRUISE SPEED (MPH)	12	12	12	12
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
1	NUMEBR OF LANES	4	3	3	3
3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1520.	3360.	3720.	3280.
3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	4800.	0.	0.	0.
4	DEMAND VOLUME (VPH)	122.	906.	360.	243.
4	DEMAND VOLUME (VPH)	638.	0.	0.	0.
5	SIGNAL CYCLE LENGTH (S)	80.			
6	GREEN PHASE LENGTH (S)	8.	39.	31.	31.
6	GREEN PHASE LENGTH (S)	47.	0.	0.	0.
7	CAPACITY (VPH)	2972.	1638.	1442.	1271.
8	PROPORTION OF VEHICLES THAT STOP	.979	.702	.678	.662
8	PROPORTION OF VEHICLES THAT STOP	.476	.000	.000	.000
9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.653	14.128	5.425	3.572
9	NUMBER OF VEHICLES THAT STOP PER CYCLE	6.745	.000	.000	.000
0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.34	1.24	.33	.24
0	LENGTH OF QUEUE (M/LANE)	14.61	30.73	11.52	7.62
0	AVERAGE EXCESS RUNNING TIME (S/VEH)	12.66	17.11	17.45	16.88
0.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200	.200	.200
1.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080	.080	.080
2.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.033	.049	.019	.013
3.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9	12.9	12.9
4.	LENGTH FOR EXCESS EMISSIONS (M)	25.7	30.7	25.7	25.7
5.	IDLING EMISSION RATE (G/S)	.550	.940	.382	.248
6.	AVERAGE EMISSION RATE (G/S-M)	.0378	.0513	.0243	.0159
7.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0797	-.1253	-.0435	-.0288
8.	FREE-FLOW EMISSION RATE (G/S-M)	.2111	.2517	.1000	.0675

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: SURFACE ARTERY/SOUTH STREET
CASE # 1 YEAR: 1986 AVERAGING TIME: 8-HOUR

LINE 1	ROAD SEGMENT ID	SAN	SAS	SN	SS
LINE 2	DEMAND VOLUME (VPH)	623.	743.	295.	199.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	4	3	3	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1900.	4200.	4650.	4100.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	6000.	0.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	100.	743.	295.	199.
LINE 6.4	DEMAND VOLUME (VPH)	523.	0.	0.	0.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.			
LINE 6.6	GREEN PHASE LENGTH (S)	8.	49.	41.	41.
LINE 6.6	GREEN PHASE LENGTH (S)	57.	0.	0.	0.
LINE 6.7	CAPACITY (VPH)	3572.	2058.	1907.	1681.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.971	.620	.630	.620
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.471	.000	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.698	12.788	5.162	3.428
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	6.843	.000	.000	.000
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.21	.57	.18	.13
LINE 8.0	LENGTH OF QUEUE (M/LANE)	14.63	26.71	10.69	7.12
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	15.89	16.79	18.93	18.58
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.018	.024	.010	.007
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.540	.691	.319	.210
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0184	.0241	.0104	.0069
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0770	-.1038	-.0412	-.0274
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1731	.2064	.0819	.0553

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection Surface Artery / South Street

Case # 2 Year 1986

1.	Road segment or intersection approach identification	SAN	SAS	SN	SS		
2.	Observed 1-hr volume (vph)						
	Observed 8-hr volume (vph)						
	Projected 1-hr peak demand (vph)	792	907	362	383		
	Projected 8-hr peak demand (vph)	649	744	297	314		
3.	Percentage cold starts						
4.	Percentage trucks and buses						
5.	Metropolitan population						
6.	Slope						
7.	Free-flow parameters						
	Number of lanes	4	3	3	3		
	Average lane width (ft)	13.7	11	14	16.6		
	Design speed (mph)		12/15				
	Highway type (see Figures 2-5)		Urban Arterial				
8.	Intersection parameters						
	Intersection designation						
	Approach width (ft)	51	33	42	32		
	Percentage right turns	64	0	51	100		
	Percentage left turns	15	1	28	0		
	Type control and description of signal controller						
9.	Area source parameters						
	Parking lot gate designation						
	Projected 1-hr peak entrance demand (vph)						
	Projected 1-hr peak exit demand (vph)						
	Projected 8-hr peak entrance demand (vph)						
	Projected 8-hr peak exit demand (vph)						
	Parking lot area (m^2)						
	Parking lot capacity (veh)						
	Running time required to access auxiliary parking (s)						
	Facility emptying time						
	Average cars per stall						
	Average area per stall (m^2)						

WORKSHEET B - CAPACITY ANALYSIS

Intersection Surface Artery / South Street

Case # 2 Year 1989

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	SAN	SAS	SN	SS
2		Free flow capacity computation:				
2.1	M_i	Number of lanes				
2.2	W_p	Adjustment for lane width (Table B-1)				
2.3	T_i	Adjustment for trucks (Table B-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	A/B	B	C	C
3.2	wa_i	Approach width with parking (ft)	1263	41	50	40
3.3		Percent right turners	264	0	57	100
3.4		Percent left turners	115	1	28	0
3.5		Metropolitan area size	2.5 mil			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	1520	4800	4200 2380	4650
4		Signalized intersection green phase and cycle length:				
4.1	$V_{i,j}$	Demand volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\sum_j \max(V_{i,j}/Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				

LUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

CTION: SURFACE ARTERY/SOUTH STREET
2 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	SAN	SAS	SN	SS
	DEMAND VOLUME (VPH)	792.	907.	362.	383.
	CRUISE SPEED (MPH)	12	12	12	12
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
.1	NUMEBR OF LANES	4	3	3	3
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1520.	3360.	3720.	3280.
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	4800.	0.	0.	0.
.4	DEMAND VOLUME (VPH)	123.	907.	362.	383.
.4	DEMAND VOLUME (VPH)	669.	0.	0.	0.
.5	SIGNAL CYCLE LENGTH (S)	80.			
.6	GREEN PHASE LENGTH (S)	8.	39.	31.	31.
.6	GREEN PHASE LENGTH (S)	47.	0.	0.	0.
.7	CAPACITY (VPH)	2972.	1638.	1442.	1271.
.8	PROPORTION OF VEHICLES THAT STOP	.979	.702	.679	.693
.8	PROPORTION OF VEHICLES THAT STOP	.479	.000	.000	.000
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.677	14.149	5.458	5.902
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	7.126	.000	.000	.000
.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.36	1.24	.34	.43
.0	LENGTH OF QUEUE (M/LANE)	15.25	30.78	11.59	12.67
.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	12.60	17.12	17.46	18.21
0.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200	.200	.200
1.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080	.080	.080
2.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.034	.050	.019	.021
3.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9	12.9	12.9
4.	LENGTH FOR EXCESS EMISSIONS (M)	25.7	30.8	25.7	25.7
5.	IDLING EMISSION RATE (G/S)	.570	.942	.385	.427
6.	AVERAGE EMISSION RATE (G/S-M)	.0393	.0513	.0245	.0269
7.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0832	-.1256	-.0437	-.0469
8.	FREE-FLOW EMISSION RATE (G/S-M)	.2200	.2519	.1006	.1064

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: SURFACE ARTERY/SOUTH STREET
CASE # 2 YEAR: 1989 AVERAGING TIME: 8-HOUR

		SAN	SAS	SN	SS
LINE 1	ROAD SEGMENT ID				
LINE 2	DEMAND VOLUME (VPH)	649.	744.	297.	314.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	4	3	3	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1900.	4200.	4650.	4100.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	6000.	0.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	101.	744.	297.	314.
LINE 6.4	DEMAND VOLUME (VPH)	548.	0.	0.	0.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.			
LINE 6.6	GREEN PHASE LENGTH (S)	8.	49.	41.	41.
LINE 6.6	GREEN PHASE LENGTH (S)	57.	0.	0.	0.
LINE 6.7	CAPACITY (VPH)	3572.	2058.	1907.	1681.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.972	.620	.630	.639
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.473	.000	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.726	12.809	5.200	5.573
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	7.203	.000	.000	.000
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.22	.57	.18	.23
LINE 8.0	LENGTH OF QUEUE (M/LANE)	15.23	26.75	10.77	11.61
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	15.77	16.80	18.94	19.34
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.019	.024	.010	.011
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.557	.693	.321	.349
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0191	.0241	.0105	.0113
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0802	-.1040	-.0415	-.0444
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1803	.2067	.0825	.0872

WORKSHEET 1 - TRAFFIC INFORMATION

Intersection Surface Artery / South Street

Case # 3 Year 1989

		JAN	JAS	SN	SS
1.	Road segment or intersection approach identification				
2.	Observed 1-hr volume (vph)				
	Observed 8-hr volume (vph)				
	Projected 1-hr peak demand (vph)	792	906	[illegible]	243
	Projected 8-hr peak demand (vph)	[illegible]	743	297	194
3.	Percentage cold starts	50/20	6		
4.	Percentage trucks and buses	1.7			
5.	Metropolitan population				
6.	Slope				
7.	Free-flow parameters				
	Number of lanes	4	3	3	3
	Average lane width (ft)	13.7	11	14	10.6
	Design speed (mph)	12/18			
	Highway type (see Figures 2-5)	1/	[illegible]		
8.	Intersection parameters				
	Intersection designation				
	Approach width (ft)	55	33	42	32
	Percentage right turns	64	0	51	100
	Percentage left turns	15	1	28	0
	Type control and description of signal controller				
9.	Area source parameters				
	Parking lot gate designation				
	Projected 1-hr peak entrance demand (vph)				
	Projected 1-hr peak exit demand (vph)				
	Projected 8-hr peak entrance demand (vph)				
	Projected 8-hr peak exit demand (vph)				
	Parking lot area (m^2)				
	Parking lot capacity (veh)				
	Running time required to access auxiliary parking (s)				
	Facility emptying time				
	Average cars per stall				
	Average area per stall (m^2)				

WORKSHEET B - CAPACITY ANALYSIS

Intersection Surface Artery / South Street

Case # 3 Year 1989

Step	Symbol	Input/Units				
1	i	Road segment (or approach) designation	SAN	SA 2	SU	SS
2		Free flow capacity computation:				
2.1	M_i	Number of lanes				
2.2	W_f	Adjustment for lane width (Table B-1)				
2.3	T_i	Adjustment for trucks (Table B-2)				
2.4	C_i	Free flow capacity				
3		Signalized intersection capacity:				
3.1	j	Green signal phase identification	A/B	B	C	C
3.2	Wa_i	Approach width with parking (ft)	1163	41	50	40
3.3		Percent right turners	5/64	0	51	100
3.4		Percent left turners	5/15	L	25	0
3.5		Metropolitan area size	2.5 mil			
3.6	$Cs_{i,j}$	Capacity service volume (vph or green)	1900/3800	4210	4400	4700
4		Signalized intersection green phase and cycle length:	1520		3360	
4.1	$V_{i,j}$	Demand Volume for approach and phase				
4.2	$V_{i,j}/Cs_{i,j}$)	Volume to green capacity ratio				
4.3	approx G/Cy	Approximate G/Cy				
4.4	$\sum_j \max(V_{i,j}Cs_{i,j})$	Sum of the maximum V/C ratios for each signal phase				
4.5	Cy	Signal cycle time (sec)				
4.6	Gj	Green phase length				
4.7	Gj/Cy	Green phase to cycle time ratio				
4.8	$C_{i,j}$	Capacity for approach i phase j				
5		Two-way stop, two-way yield or uncontrolled intersection:				
5.1	V_m+V_n	Major street two-way volume				
5.2	C_i	Cross street capacity				
6		Four-way stop intersections:				
6.1	V_i	Approach volume				
6.2	Spi	Demand split on cross streets				
6.3	C_i	Capacity of approach				
7	C_i	Approach capacity $\sum_j C_{i,j}$ 5.2 for a four-way stop or 6.3 for a two-way stop				

OLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

ECTION: SURFACE ARTERY/SOUTH STREET
3 YEAR: 1989 AVERAGING TIME: 1-HOUR

	ROAD SEGMENT ID	SAN	SAS	SN	SS
	DEMAND VOLUME (VPH)	792.	906.	362.	243.
	CRUISE SPEED (MPH)	12	12	12	12
	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
.1	NUMEBR OF LANES	4	3	3	3
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1520.	3360.	3720.	3280.
.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	4800.	0.	0.	0.
.4	DEMAND VOLUME (VPH)	123.	906.	362.	243.
.4	DEMAND VOLUME (VPH)	669.	0.	0.	0.
.5	SIGNAL CYCLE LENGTH (S)	80.			
.6	GREEN PHASE LENGTH (S)	8.	39.	31.	31.
.6	GREEN PHASE LENGTH (S)	47.	0.	0.	0.
.7	CAPACITY (VPH)	2972.	1638.	1442.	1271.
.8	PROPORTION OF VEHICLES THAT STOP	.979	.702	.679	.662
.8	PROPORTION OF VEHICLES THAT STOP	.479	.000	.000	.000
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.677	14.128	5.458	3.572
.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	7.126	.000	.000	.000
7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.36	1.24	.34	.24
8.0	LENGTH OF QUEUE (M/LANE)	15.25	30.73	11.59	7.62
9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	12.60	17.11	17.46	16.88
10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.200	.200	.200	.200
11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.080	.080	.080	.080
12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.034	.049	.019	.013
13.	LENGTH OF ACC. AND DEC. (M)	12.9	12.9	12.9	12.9
14.	LENGTH FOR EXCESS EMISSIONS (M)	25.7	30.7	25.7	25.7
15.	IDLING EMISSION RATE (G/S)	.570	.940	.385	.248
16.	AVERAGE EMISSION RATE (G/S-M)	.0393	.0513	.0245	.0159
17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0832	-.1253	-.0437	-.0288
18.	FREE-FLOW EMISSION RATE (G/S-M)	.2200	.2517	.1006	.0675

EPA VOLUME 9 (REVISED) INDIRECT SOURCE GUIDELINE MODEL - WORKSHEET #2

INTERSECTION: SURFACE ARTERY/SOUTH STREET
CASE # 3 YEAR: 1989 AVERAGING TIME: 8-HOUR

	ROAD SEGMENT ID	SAN	SAS	SN	SS
LINE 1					
LINE 2	DEMAND VOLUME (VPH)	649.	743.	297.	199.
LINE 4	CRUISE SPEED (MPH)	18	18	18	18
LINE 5	FREE-FLOW EMISSIONS (G-VEH/M)	1.0000	1.0000	1.0000	1.0000
LINE 6.1	NUMEBR OF LANES	4	3	3	3
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	1900.	4200.	4650.	4100.
LINE 6.3	CAPACITY SERVICE VOLUME (VPH OF GREEN)	6000.	0.	0.	0.
LINE 6.4	DEMAND VOLUME (VPH)	101.	743.	297.	199.
LINE 6.4	DEMAND VOLUME (VPH)	548.	0.	0.	0.
LINE 6.5	SIGNAL CYCLE LENGTH (S)	100.			
LINE 6.6	GREEN PHASE LENGTH (S)	8.	49.	41.	41.
LINE 6.6	GREEN PHASE LENGTH (S)	57.	0.	0.	0.
LINE 6.7	CAPACITY (VPH)	3572.	2058.	1907.	1681.
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.972	.620	.630	.620
LINE 6.8	PROPORTION OF VEHICLES THAT STOP	.473	.000	.000	.000
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	2.726	12.788	5.200	3.428
LINE 6.9	NUMBER OF VEHICLES THAT STOP PER CYCLE	7.203	.000	.000	.000
LINE 7.0	AVERAGE NUMBER OF VEHICLES IN QUEUE	.22	.57	.18	.13
LINE 8.0	LENGTH OF QUEUE (M/LANE)	15.23	26.71	10.77	7.12
LINE 9.0	AVERAGE EXCESS RUNNING TIME (S/VEH)	15.77	16.79	18.94	18.58
LINE 10.	EMISSIONS FROM ACCELERATION (G/VEH-M)	.140	.140	.140	.140
LINE 11.	EMISSIONS FROM DECELERATION (G/VEH-M)	.050	.050	.050	.050
LINE 12.	EMISSION RATE FOR ACC. AND DEC. (G/M-S)	.019	.024	.010	.007
LINE 13.	LENGTH OF ACC. AND DEC. (M)	29.0	29.0	29.0	29.0
LINE 14.	LENGTH FOR EXCESS EMISSIONS (M)	57.9	57.9	57.9	57.9
LINE 15.	IDLING EMISSION RATE (G/S)	.557	.691	.321	.210
LINE 16.	AVERAGE EMISSION RATE (G/S-M)	.0191	.0241	.0105	.0069
LINE 17.	ADJUSTED EXCESS EMISSION RATE (G/S-M)	-.0802	-.1038	-.0415	-.0274
LINE 18.	FREE-FLOW EMISSION RATE (G/S-M)	.1803	.2064	.0825	.0553

WORKSHEET 3 - AREA SOURCE EMISSIONS COMPUTATION

Area Source 125 Summer Street Parking Garage

Case # 2 Year 1999(AM) Averaging Time 1 ~~Hour~~

Step	Symbol	Input/Units	Traffic Stream			
1	Brt	Base running time	IN	[illegible]		
1.1		Base approach time(s)	1.0			
1.2		Base entrance time(s)	5			
1.3		Base movement-in time(s)	102			
1.4		Base stop, base start time(s)	10			
1.5		Base movement-out time(s)	102			
1.6		Base exit time(s)	10			
1.7		Base departure time(s)	1.0			
1.8		Total base running time(s)	231			
2	A	Area of parking lot (m^2)				
3	i	Entrance approach identification	IN			
4	Ve_i	Entrance demand volume. (vph)	218			
5	Ce_i	Entrance approach capacities (vph)	720*			
6	i	Exit approach identification		+		
7	Vx_i	Exit demand volume (vph)		0		
8	Cx_i	Exit approach capacities (vph)		NA		
9		Number of parking spaces occupied				
10	F	Emissions	128.72	0.00		
11	Pc	Capacity of parking lot (veh)	238			
12	Rmi	Excess movement-in time(s)	0			
13	Fet	Facility emptying time(s)	2380			
14		Excess running time				
14.1	Ve_i/Ce_i	Entering volume-to-capacity ratio	.30			
14.2	Vx_i/Cx_i	Exiting volume-to-capacity ratio		0.0		
14.3	Re_i	Excess running time entering parking lot	2.17			
14.4	Rx_i	Excess running time exiting parking lot		0.0		
15	Te_i	Total entering running time (s/veh)	118			
16	Rmo	Excess running time moving out of parking stalls (s/veh)		0.0		
17	Tx_i	Total exiting running time (s/veh)	116			
18	Qa	Total emission rate from a parking lot ~~g/m - s~~ (g/s)	2.56 g/s			
19	Qa'	Area source emission rate without the emissions from internal road segment. i				

*Assumes an entrance gate capacity of 5 vehicles per minute

WORKSHEET 3 - AREA SOURCE EMISSIONS COMPUTATION

Area Source 125 Summer Street Parking Garage
Case # 2 Year 1989 (PM) Averaging Time 1 Hour (C)

Step	Symbol	Input/Units	Traffic Stream			
1	Brt	Base running time	IN	OUT		
1.1		Base approach time(s)	1.0			
1.2		Base entrance time(s)	5			
1.3		Base movement-in time(s)	102			
1.4		Base stop, base start time(s)	10			
1.5		Base movement-out time(s)	102			
1.6		Base exit time(s)	10			
1.7		Base departure time(s)	1.0			
1.8		Total base running time(s)	231			
2	A	Area of parking lot (m^2)				
3	i	Entrance approach identification	IN			
4	Ve_i	Entrance demand volume (vph)	2			
5	Ce_i	Entrance approach capacities (vph)	720			
6	i	Exit approach identification		OUT		
7	Vx_i	Exit demand volume (vph)		222		
8	Cx_i	Exit approach capacities (vph) *		725		
9		Number of parking spaces occupied				
10	F	Emissions	128.76			
11	Pc	Capacity of parking lot (veh)	238			
12	Rmi	Excess movement-in time(s)	0			
13	Fet	Facility emptying time(s)	2280			
14		Excess running time				
14.1	Ve_i/Ce_i	Entering volume-to-capacity ratio	.003			
14.2	Vx_i/Cx_i	Exiting volume-to-capacity ratio		.31		
14.3	Re_i	Excess running time entering parking lot	.01			
14.4	Rx_i	Excess running time exiting parking lot		2.12		
15	Te_i	Total entering running time (s/veh)	116			
16	Rmo	Excess running time moving out of parking stalls (s/veh)	2			
17	Tx_i	Total exiting running time (s/veh)	118			
18	Qa	Total emission rate from a parking lot (g/m^2 - s)	2.63 g/s			
19	Qa'	Area source emission rate without the emissions from internal road segment. i				

* $C = \frac{V_0 z^{-a}}{1 - e^{-a}}$ $q = V_0 t / 3600 = (173)(4.5) / 3600 = .22$

V_0 = Street volume = 346/2 lanes = 173

t = 4.5 sec (from CO analysis)

C = 725

WORKSHEET 3 - AREA SOURCE EMISSIONS COMPUTATION

Area Source 125 Summer Street Parking Garage

Case # 2 Year 1989 Averaging Time 8 Hour

Step	Symbol	Input/Units	Traffic Stream			
1	Brt	Base running time	IN	OUT		
1.1		Base approach time(s)	1.0			
1.2		Base entrance time(s)	5			
1.3		Base movement-in time(s)	102			
1.4		Base stop, base start time(s)	10			
1.5		Base movement-out time(s)	102			
1.6		Base exit time(s)	10			
1.7		Base departure time(s)	1.0			
1.8		Total base running time(s)	231			
2	A	Area of parking lot (m^2)				
3	i	Entrance approach identification	IN			
4	Ve_i	Entrance demand volume (vph)	3			
5	Ce_i	Entrance approach capacities (vph)	720			
6	i	Exit approach identification		OUT		
7	Vx_i	Exit demand volume (vph)		30		
8	Cx_i	Exit approach capacities (vph) *		723		
9		Number of parking spaces occupied				
10	F	Emissions	61.72			
11	Pc	Capacity of parking lot (veh)	230			
12	Rmi	Excess movement-in time(s)	0			
13	Fet	Facility emptying time(s)	2380			
14		Excess running time				
14.1	Ve_i/Ce_i	Entering volume-to-capacity ratio	.004			
14.2	Vx_i/Cx_i	Exiting volume-to-capacity ratio		.04		
14.3	Re_i	Excess running time entering parking lot	.02			
14.4	Rx_i	Excess running time exiting parking lot		.21		
15	Te_i	Total entering running time (s/veh)	116			
16	Rmo	Excess running time moving out of parking stalls (s/veh)	0			
17	Tx_i	Total exiting running time (s/veh)	116			
18	Qa	Total emission rate from a parking lot (g/m^2 - s)	0.18 g/s			
19	Qa'	Area source emission rate without the emissions from internal road segment. i				

* $C = \frac{V_0 e^{-a}}{1 - e^{-a}}$

$a = V_e t / 3600 = (117)(4.5)/3600 = .15$

$V_e = 234(.83)/2$ lanes $= 117$

$t = 4.5$ sec

$c = 723$

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